SCIENCE AERONAUTICS & TECHNOLOGY
FY 2003 ESTIMATES BUDGET SUMMARY
OFFICE OF AEROSPACE TECHNOLOGY
SUMMARY OF RESOURCE REQUIREMENTS

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET	Page Number
	(Millions of Dollars)			
Revolutionize Aviation	**572.5**	**599.4**	**541.4**	
Aviation Safety Program	75.8	96.1	95.0	SAT 4-14
Vehicle Systems Program	370.8	369.4	321.3	SAT 4.22
Airspace Systems Program	125.9	133.9	125.1	SAT 4-40
Advanced Space Transportation	**391.2**	**578.0**	**879.4**	
2nd Generation Reusable Launch Vehicle Program (SLI)	289.4	467.0	759.2	SAT 4-52
Space Transportation & Launch Technology (STLT)	101.8	111.0	120.2	SAT 4-61
Pioneer Revolutionary Technology	**278.0**	**276.7**	**274.9**	
Computing, Information, & Communications Technology (CICT)	165.6	155.9	154.0	SAT 4-67
Engineering for Complex Systems	--	28.0	28.0	SAT 4-77
Enabling Concepts & Technologies	112.4	92.8	92.9	SAT 4-83
Commercial Technology	**162.4**	**163.8**	**146.9**	
Commercial Programs and Technology Transfer Agents	51.3	48.7	35.6	SAT 4-89
Small Business Innovation Research Programs	111.1	115.1	111.3	SAT 4-92
Investments	**[18.0]**	**[29.5]**	**[14.0]**	
[Construction of Facilities - included above]	[18.0]	[29.5]	[14.0]	
Aerospace Institutional Support	**808.7**	**889.8**	**973.2**	SAT 4-93
Total	**2,212.8**	**2,507.7**	**2,815.8**	

OFFICE OF AEROSPACE TECHNOLOGY

DISTRIBUTION OF PROGRAM AMOUNT BY INSTALLATION
($Millions)

	FY 2001*	FY 2002	FY 2003
		(Millions of Dollars)	
Johnson Space Center	28.2	29.2	26.7
Kennedy Space Center	22.9	33.5	33.7
Marshall Space Flight Center	331.3	466.4	794.1
Ames Research Center	435.2	474.4	429.7
Langley Research Center	464.1	539.7	545.2
Glenn Research Center	438.3	459.2	479.1
Goddard Space Flight Center	85.1	89.3	73.7
Jet Propulsion Laboratory	42.2	34.3	37.6
Dryden Flight Research Center	155.0	150.3	160.8
Stennis Space Center	76.5	49.9	38.4
Headquarters	134.0	181.5	196.8
Total	**2,212.8**	**2,507.7**	**2,815.8**

* FY 2001 restructured to reflect new FY 2002 Two Appropriation Structure

Aerospace Technology Direct Full-Time Equivalent (FTE) Workyears	**4581**	**4495**	**4618**

2000 STRATEGIC PLAN LINKAGE TO THIS BUDGET

The Aerospace Technology Enterprise mission is to advance U. S. preeminence in aerospace research and technology. The Enterprise aims to radically improve air travel, making it safer, faster, and quieter as well as more affordable, accessible, and environmentally sound. The Enterprise is also working to develop more affordable, reliable, and safe access to space; improve the way in which air and space vehicles are designed and built; and ensure new aerospace technologies are available to benefit the public.

The Aerospace Technology Enterprise program work breakdown structure (WBS) has been reorganized to create a clear linkage between National policies, the Enterprise strategic goals and the program management structure. This restructuring creates an unambiguous linkage from the Agency strategic plan to this budget and provides a foundation for transparent, measurable performance reporting through the Government Performance and Results Act. This change also ensures that the Agency fulfills the intent of the language in House Report (107-272) accompanying H.R. 2620, "Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriations Act, 2002" whereby:

The conferees agree with the House that by merging the budgets for aeronautics and space into a single 'aerospace technology' program element several years ago, NASA has made it virtually impossible to account for the current investment in aeronautics. For this reason, the conferees direct NASA to reestablish a consolidated aeronautics line in the fiscal year 2003 budget submission that comprehensively covers all research base, focused, and advanced technology programs, and related test facilities and civil service costs. NASA should also provide a clear budget crosscut identifying all aeronautics programmatic activities in the current budget structure in its initial fiscal year 2002 operating plan.

The Enterprise approach for implementing the program begins with investment decisions based on rigorous systems analysis. By integrating and consolidating long- and mid-term technology development with customer needs, the Enterprise will develop a stronger, clearer linkage between basic research and advanced development. Independent programmatic and expert reviews will provide supplemental information that will be incorporated in management decisions. Annual program reviews will be used to measure progress (technical, schedule and cost) against requirements and deliverables, and outside expert technical reviews will assure the quality of the products, research performers, and future directions to meet strategic goals. The Enterprise will strengthen National government and industry partnerships with clear roles with investments balanced across in-house efforts, industry and academia. Investments at the NASA Centers will concentrate on critical core competencies that can enable new capabilities and missions and that cannot be developed or performed elsewhere.

A trace from the program structured presented in the FY 2002 request to the proposed structure is detailed in the 4 following pages. Additionally, while the program names have changed to be consistent with the new structure, only in a few cases have the programs been reformulated to increase investment in "leap-frog" technologies (primarily Vehicle Systems program under Revolutionize Aviation and Enabling Concepts and Technologies under Pioneer Revolutionary Technology). The FY 2003 request is largely consistent with the planned out years of the FY 2002 request.

Changes to Aerospace Technology Program Structure

FY 02 Structure

Aerospace Focused R&T Programs

« Aviation Safety

« Aviation System Capacity

- D Advanced Air Transportation Technology
- D Virtual Air Space Modeling

« Small Aircraft Transportation System

« Ultra-Efficient Engine Technology

« Quiet Aircraft Technology

« 2nd Generation RLV

Aerospace Base R&T Programs

« Vehicle Systems Technology

« Propulsion & Power

« Flight Research

« Space Transfer & Launch Tech

« Computing, Information & Communication Tech

- D Aerospace Operations Research
- D Information Technology Base
- D Autonomy *
- D Intelligent Systems (IS)
- D Design for Safety

« Space Base

« Space NRAs

FY 03 Structure

Revolutionize Aviation Programs

« Aviation Safety

« Airspace Systems

- D Advanced Air Transportation Technology
- D Virtual Air Space Modeling
- D Small Aircraft Transportation System
- D Aerospace Operations Research

« Vehicle Systems

- D Ultra-Efficient Engine Technology
- D Quiet Aircraft Technology
- D 21st Century Aircraft
- D Breakthrough Technologies
- D Propulsion & Power
- D Flight Research
- D Advanced Concepts

Advance Space Transportation Programs

« 2nd Generation RLV

« Space Transfer & Launch Technology

Pioneer Revolutionary Technology Programs

« Computing, Information & Communication Tech

- D Information Technology Strategic Research
- D Computing, Network & Information Systems
- D Space Communications
- D Intelligent Systems (IS)

« Engineering for Complex Systems

« Enabling Concepts & Technologies

Changes to Aerospace Technology Program Structure

Trace from FY 2001 President's Budget to New FY 2003 Budget Structure

Aerospace Technology Budget Structure Crosswalk		**FY 2003 Budget Structure**								
FY 2001 Budget (Millions of Dollars)		**Revolutionaize Aviation**			**Advanced Space Transportation**		**Pioneer Revolutionary Technology**			**Commercial Technology**
FY 2002 Budget Structure	FY 2001 Initial Op Plan	Aviation Safety	Vehicle Systems	Airspace Systems	2nd Generation RLV	Space Transfer & Launch Tech	CICT	Engineering for Complex Systems	Enabling Concepts & Technologies	Commercial Technology Programs
Aerospace Technology Summary	**1,404.1**	**75.8**	**370.8**	**125.9**	**289.4**	**101.8**	**165.6**	**0.0**	**112.4**	**162.4**
Research and Technology Base	**714.1**									
Computing, Information & Communications Technology (CICT)	158.2		10.5	16.9			130.6		0.2	
Vehicle System Technology *Base*	184.2		134.3			11.4			38.5	
Propulsion & Power	129.1	4.9	63.7			22.1	12.9		25.5	
Flight Research	83.3		83.3							
Rotorcraft	31.6			31.6						
Space Transfer & Launch Technology	76.6					68.3			8.3	
Aerospace Base NASA Research Announcements	39.9								39.9	
Aerospace Investments	11.2		11.2							
Focused Programs	**527.6**									
High Performance Computing & Communications	22.1						22.1			
Aviation Systems Capacity	68.4			68.4						
Aviation Safety	70.9	70.9								
Ultra-Efficient Engine Technology (UEET)	47.9		47.9							
Small Air Transport System (SATS)	9.0			9.0						
Quiet Airplane Technology (QAT)	19.9		19.9							
X-34 Technology Demonstrator	17.9				17.9					
2nd Generation RLV	271.5				271.5					
Commercial Technology Programs	**162.4**									162.4

Changes to Aerospace Technology Program Structure

Trace from FY 2002 President's Budget to New FY 2003 Budget Structure

Aerospace Technology Budget Structure Crosswalk		**FY 2003 Budget Structure**								
FY 2002 Budget (Millions of Dollars)		**Revolutionaize Aviation**			**Advanced Space Transportation**		**Pioneer Revolutionary Technology**			**Commercial Technology**
FY 2002 Budget Structure	FY 2002 Initial Op Plan	Aviation Safety	Vehicle Systems	Airspace Systems	2nd Generation RLV	Space Transfer & Launch Tech	CICT	Engineering for Complex Systems	Enabling Concepts & Technologies	Commercial Technology Programs
Aerospace Technology Summary	**1,617.9**	**96.1**	**369.4**	**133.9**	**467.0**	**111.0**	**155.9**	**28.0**	**92.8**	**163.8**
Research and Technology Base	**721.2**									
Computing, Information & Communications Technology (CICT)	206.4	4.0	6.0	11.5		5.0	151.9	28.0		
Vehicle System Technology *Base*	207.5		154.5			20.5			32.5	
Propulsion & Power	126.1	6.1	79.8			21.7	4.0		14.5	
Flight Research	59.1		59.1							
Rotorcraft	12.5			12.5						
Space Transfer & Launch Technology	69.6					63.8			5.8	
Aerospace Base NASA Research Announcements	40.0								40.0	
Aerospace Investments	0.0									
Focused Programs	**732.9**									
High Performance Computing & Communications	0.0									
Aviation Systems Capacity	94.4			94.4						
Aviation Safety	86.0	86.0								
Ultra-Efficient Engine Technology (UEET)	50.0		50.0							
Small Air Transport System (SATS)	15.5			15.5						
Quiet Airplane Technology (QAT)	20.0		20.0							
X-34 Technology Demonstrator	0.0									
2nd Generation RLV	467.0				467.0					
Commercial Technology Programs	**163.8**									163.8

Changes to Aerospace Technology Program Structure

Trace from FY 2003 Budget Request to New FY 2003 Budget Structure

Aerospace Technology Budget Structure Crosswalk		**FY 2003 Budget Structure**									
FY 2003 Budget (Millions of Dollars)		**Revolutionaize Aviation**			**Advanced Space Transportation**		**Pioneer Revolutionary Technology**			**Commercial Technology**	
FY 2002 Budget Structure	FY 2003 PRES BUDGET	Aviation Safety	Vehicle Systems	Airspace Systems	2nd Generation RLV	Space Transfer & Launch Tech	CICT	Engineering for Complex Systems	Enabling Concepts & Technologies	Commercial Technology Programs	
Aerospace Technology Summary	**1,842.6**	**95.0**	**321.3**	**125.1**	**759.2**	**120.2**	**154.0**	**28.0**	**92.9**	**146.9**	
Research and Technology Base	**666.9**										
Computing, Information & Communications Technology (CICT)	202.4	4.0	9.9	10.5			150.0	28.0			
Vehicle System Technology *Base*	156.9		125.6						31.3		
Propulsion & Power	74.9	6.0	50.2				4.0		14.7		
Flight Research	65.6		65.6								
Rotorcraft	0.0										
Space Transfer & Launch Technology	127.1					120.2			6.9		
Aerospace Base NASA Research Announcements	40.0								40.0		
Aerospace Investments	0.0										
Focused Programs	**1,028.8**										
High Performance Computing & Communications	0.0										
Aviation Systems Capacity	94.6			94.6							
Aviation Safety	85.0	85.0									
Ultra-Efficient Engine Technology (UEET)	50.0		50.0								
Small Air Transport System (SATS)	20.0			20.0							
X-34 Technology Demonstrator	0.0										
Quiet Airplane Technology (QAT)	20.0		20.0								
2nd Generation RLV	759.2				759.2						
Commercial Technology Programs	**146.9**									146.9	

Enterprise Goals	Objectives	Strategy	Enabling Program / Mission
Revolutionize Aviation	**Increase Safety -** Reduce the aircraft accident rate by a factor of 5 by 2007 and by a factor of 10 by 2022	**System Monitoring and Modeling -** Develop technologies for using the vast amounts of data available within the aviation system to identify, understand, and correct aviation system problems before they lead to accidents. **Accident Prevention -** Identify interventions and develop technologies to eliminate the types of accidents that can be categorized as "recurring." **Accident Mitigation -** Develop technologies to reduce the risk of injury in the unlikely event of an accident.	**Aviation Safety Program** **Vehicle Systems Program**
	Reduce Emissions - Reduce oxides of nitrogen (NOx) emissions of future aircraft by 70% by 2007 and by 80% by 2022 (Baseline: 1996 ICAO Standard). Reduce carbon dioxide (CO_2) emissions of future aircraft by 25% by 2007 and by 50% by 2022	**Airframe Weight and Drag Reduction -** Develop airframe technologies that reduce fuel consumption and therefore reduce CO_2 and NO_x emissions. **Propulsion Optimization -** Develop advanced engine system technologies to reduce emissions such as NO_x that have an impact on local air quality and those such as CO_2 that affect the global climate. **Operation Optimization -** Develop more efficient operations at and around airports, in order to reduce aviation fuel burn and thereby reduce emissions. **Alternative Vehicle Concepts -** Develop advanced concepts for propulsion systems, airframe structures, and fuels that dramatically reduce or completely eliminate emissions from civil aviation aircraft.	**Vehicle Systems Program**
	Reduce Noise - Confine noise within the airport boundary by reducing the perceived noise of future aircraft by a factor of two (10 decibels) by 2007 and by a factor of four (20 decibels) by 2022 using 1997 subsonic aircraft technology as the baseline	**Propulsion System Source Noise Reduction -** Develop technologies to reduce engine noise at the source. **Aircraft System Source Noise Reduction -** Develop technologies to diminish airframe-related noise. **Operational Noise Reduction -** Develop advanced aircraft operating procedures, including steeper glide-slopes and precision, wind-compensated flight paths.	**Vehicle Systems Program**

Enterprise Goals	Objectives	Strategy	Enabling Program / Mission
	Increase Capacity - Double the capacity of the aviation system within 10 years and triple within 25 years based on 1997 level	**Infrastructure and Operation Optimization -** Optimize use of the current infrastructure without adding new airports or new runways by developing Air Traffic Management (ATM) technologies that increase the efficiency and capacity of the NAS. **Alternative Vehicle Concepts -** Develop new civil aviation vehicle concepts that are designed to use segments of the NAS not suited for traditional commercial aircraft, such as short runways and vertical take-off and landing pads. **Alternative Infrastructure Concepts -** Develop entirely new concepts and systems, such as fully automated towers and airports that would increase the use and capacity of the Nation's 5000 public-use airports.	**Airspace Systems Program** **Vehicle Systems Program**
	Increase Mobility - Reduce the time for inter-city door-to-door transportation by half by 2007 and by two-thirds by 2022, and reduce long-haul transcontinental travel time by half by 2022	**Small Aircraft Transportation -** This thrust will focus on developing vehicle, communication, and information technologies to allow small aircraft to operate easily and affordably at small, underused airports in most weather conditions. **Supersonic Transportation -** Develop technologies critical to the economic viability of supersonic transport, such as propulsion concepts that meet stringent noise and emissions criteria. **Advanced Mobility Concepts and Technology -** Investigate non-traditional vehicles and operations concepts to take advantage of operational airspace that is currently underused.	**Airspace Systems Program** **Vehicle Systems Program**

Enterprise Goals	Objectives	Strategy	Enabling Program / Mission
Advance Space Transportation	**Mission Safety -** Reduce the incidence of crew loss for a second generation Reusable Launch Vehicle (RLV) to 1 in 10,000 missions (a factor of 40) by 2010 and to less than 1 in 1 million missions (an additional factor of 100) for a third generation RLV by 2025	**Reusable and Robust Propulsion Systems -** Develop technologies for inherent reliability, more robust subsystems, and an increased performance margin for propulsion and power systems. **Integrated Vehicle Health Management (IVHM) -** Develop advanced sensors and algorithms to integrate intelligence, such as real-time failure detection and isolation, into vehicle systems. **Crew Escape -** Develop systems to remove the crew safely from a vehicle in the event of catastrophic failure during the highest risk phases of a mission, including vehicle ascent and descent.	**2nd Generation Reusable Launch Vehicle Program** **Space Transfer and Launch Technology Program**
	Mission Affordability - Reduce the cost of delivering a payload to Low-Earth Orbit (LEO) to $1,000 per pound (a factor of 10) by 2010 and to $100 per pound (an additional factor of 10) by 2025. Reduce the cost of inter-orbital transfer by a factor of 10 within 15 years and by an additional factor of 10 by 2025	**Reusable and Robust Propulsion Systems -** Develop long-life, highly reusable engine systems and inherently reliable integrated propulsion systems. **Low-Cost, Lightweight Materials and Structures -** Reduce the overall system weight of vehicles using lightweight, long-life primary structures and low-cost metallic and non-metallic propellant tanks. **Operations Optimization -** Develop the capability for autonomous checkout and vehicle control, modular payload systems, and new launch site operations. **Risk Reduction -** Develop key technologies for full-scale development of a second-generation RLV system.	**2nd Generation Reusable Launch Vehicle Program** **Space Transfer and Launch Technology Program**

Enterprise Goals	Objectives	Strategy	Enabling Program / Mission
	Mission Reach - Reduce the time for planetary missions by a factor of 2 by 2015 and by a factor of 10 by 2025.	**Advanced Propulsion Concepts** - Identify and develop breakthrough technology for advanced propulsion systems. **Materials and Structures** - Develop lightweight airframes, tanks, and micro-components using nanotechnology and ultra-high temperature ceramics.	**Enabling Concepts & Technologies Program**
Pioneer Technology Innovation	**Engineering Innovation** - Within 10 years, demonstrate advanced full life-cycle design and simulation tools, process, and virtual environments in critical NASA engineering applications; and within 25 years, demonstrate an integrated, high-confidence engineering environment that fully simulates advanced aerospace systems, their environments, and their missions	**Process and Concept Innovation** - Develop new processes and concepts for accomplishing full-life-cycle ("cradle-to-grave") planning and design of new, revolutionary aerospace systems. **Validation and Implementation** - Develop technologies and concepts for new ways of certifying and fielding new aerospace systems. **Information Technologies** - Develop computational capabilities and knowledge bases necessary to design new aerospace systems. **Advanced Engineering and Analysis Technologies** - Develop design tools and the ability to model any part of a new vehicle design during any part of the system's lifespan and under all operating conditions and environments.	**Computing, Information, & Communica-tions Technology Program** **Engineering for Complex Systems Program**

Enterprise Goals	Objectives	Strategy	Enabling Program / Mission
	Technology Innovation - Within 10 year, integrate revolutionary technologies to explore fundamentally new aerospace system capabilities and missions; and within 25 years, demonstrate new aerospace capabilities and new mission concepts in flight	**Core Competencies -** Build and advance the critical technology competencies that have potential for major benefits to aerospace applications that cannot be found in government, academia, or industry today. **Enabling New Missions -** Develop technologies for missions that are currently unrealistic, from personal air transportation to interstellar travel. This thrust will remove barriers such as high technology costs, limits to human endurance, and immense mission timeframes, to open exciting new possibilities. **Enabling New Capabilities -** Develop capabilities that are not possible today, such as autonomy sufficient to conduct an entire mission without human intervention, or self-repair of a vehicle's skin.	**Computing, Information, & Communica-tions Technology Program** **Enabling Concepts & Technologies Program**

Enterprise Goals	**Objectives**	**Strategy**	**Enabling Program / Mission**
Commercialize Technology	**Innovation-**NASA's CT Program supports the NASA R&D mission through partnerships with industry. It facilitates the transfer of NASA inventions, innovations, and discoveries developed by NASA personnel or in conjunction with its many partnerships to the private sector for potential commercial application. The SBIR program (inclusive of the Small Business Tech Transfer programs) helps NASA develop innovative technologies by providing competitive research contracts to U.S.-owned small businesses, and by fostering commercialization	**Industry Partnerships -** The establishment of productive technology development and application partnerships with industry. **Outreach -** An extensive outreach program (technology dissemination and marketing); An electronic commerce/information network (via the Internet) that greatly facilitates the transfer of technology and allows very efficient implementation of our technology business contacts and services; Training and education of NASA employees to emphasize program relevance to national needs and to facilitate program implementation; **Metrics -** The use of metrics that address management processes as well as bottom-line results.	**Commercial Programs** **Small Business SBIR/STTR Programs**

BASIS OF FY 2003 FUNDING REQUIREMENT

AVIATION SAFETY PROGRAM (AvSP)

Web Address: http://avsp.larc.nasa.gov/

	FY 2001	FY 2002	FY 2003
		(Millions of Dollars)	
Aviation Safety Program	**75.8**	**96.1**	**95.0**
Vehicle Safety Technologies	43.0	58.0	49.8
Weather Safety Technologies	17.4	17.9	20.9
System Safety Technologies	15.4	20.2	24.3

DESCRIPTION/JUSTIFICATION

The worldwide commercial aviation major accident rate has been nearly constant over the past two decades. While the rate is very low (approximately one hull loss per two million departures), increasing traffic over the years has resulted in the absolute number of accidents also increasing. The worldwide demand for air travel is expected to increase even further over the coming two decades - more than doubling by 2017. Without an improvement in the accident rate, such increasing traffic volume would lead to 50 or more major accidents a year — a near weekly occurrence. Given the very visible, damaging, and tragic effects of even a single major accident, even approaching this number of accidents would have an unacceptable impact upon the public's confidence in the aviation system, and impede the anticipated growth of the commercial air-travel market. The safety of the general aviation (GA) system is also critically important. The current GA accident rate is many times greater than that of scheduled commercial transport operations. The GA market may grow significantly in future years. Safety considerations must be removed as a barrier if this growth is also to be realized. For commercial aircraft, Controlled-Flight Into Terrain (CFIT) and loss of control account for the largest number of accidents, with weather, approach and landing, and on-board fire as additional significant accident categories. For each of these categories, human error is most often cited as the prime-contributing factor.

In February 1997, to aggressively address these issues, a new national goal to reduce the fatal accident rate for aviation by 80% within 10 years was established. This national aviation safety goal is an ambitious and clear challenge to the aviation community. NASA responded to the challenge with an immediate major program planning effort to define where NASA research could contribute to meeting this goal. Four industry- and government-wide workshops were conducted in early 1997 to define research needs with four hundred persons from over one hundred industry, government, and academic organizations actively participating. This effort led to NASA's aviation safety initiative and a redirection of the Aeronautics Research and Technology Base in FY 1998 to immediately augment aviation safety research. The Aviation Safety Program (AvSP) is NASA's next step in responding to the challenge. Consistent with the national goals set in 1997, the goal of the AvSP is to develop and demonstrate technologies that contribute to a reduction in the aviation accident fatal rate by a factor of 5 by the year 2007 compared to the 1994-1996 average.

The NASA AvSP approach for contributing to the national goal is to develop and demonstrate technologies and strategies to improve aviation safety by reducing both aircraft accident and fatality rates. Program planning gives high priority to those strategies that address factors determined to be the largest contributors to fatal accidents as well as those that address multiple classes of factors. Research and technology development will address accidents involving hazardous weather, CFIT, human-error-caused accidents and incidents, and mechanical or software malfunctions. The safety program will emphasize not only accident rate reduction, but also a decrease in injuries and fatalities when accidents do occur. The program will develop and integrate information technologies needed for a safer aviation system. This effort will provide support to pilots and air traffic controllers, as well as providing information that will be used to assess and identify potentially unsafe situations and trends before they lead to accidents. The focus of each program project is the development of one or more prevention, intervention, or mitigation strategies aimed at one or more causal, contributory, or circumstantial factors associated with aviation accidents.

The AvSP will work as partners with the Federal Aviation Administration (FAA) in implementing the program and will maintain close coordination with the Department of Defense and other government agencies. Additionally, the program will work in concert with the full spectrum of commercial, rotorcraft, and GA industry manufacturers, suppliers, and operators in implementing the effort. Langley Research Center (LaRC) is the program's Lead Center and works as a team with program personnel at Ames Research Center (ARC), Glenn Research Center (GRC), Dryden Flight Research Center (DFRC), and Goddard Space Flight Center (GSFC).

The AvSP programmatic and technical approach has been developed in close cooperation with the FAA as well as the broad aviation community. The Aviation Safety Program Manager is a member of the Commercial Aviation Safety Team and the General Aviation Joint Steering Committee, the government/industry leadership groups developing and managing overall National aviation safety strategies. NASA aviation safety research and development efforts will therefore complement both FAA and industry activities as a coordinated effort.

NASA's Aerospace Technology Enterprise has set aside funding for continuing aviation safety improvements beyond the current AvSP timeline. These new efforts, reflected as a Future Aviation Safety Technologies project, are planned to begin in FY05 and will build on the success and foundation of AvSP. A decision point will be inserted prior to the start of these new efforts to determine the appropriate needs and content of these new efforts.

STRATEGIC OBJECTIVE:	**PROGRAM APPROACH:**
Increase Safety	Program is structured around developing technologies along three major thrusts: (1) Aviation system monitoring and modeling to help aircraft and aviation system operators identify unsafe conditions before they lead to accidents. (2) Accident prevention in targeted accident categories, including system-wide, single aircraft, and weather. (3) Accident mitigation, is focused on increasing accident survivability to reduce fatalities in those cases when accidents do occur

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Revolutionize Aviation
Strategic Plan Objectives Supported: Increase Safety
Performance Plan Metrics Supported: APG 3R1

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-03 Change	Comment
Simulation database for adverse conditions and loss of control		1/01	9/00	Complete	Completed development of preliminary simulation database, mathematical models, and 6-degree of freedom (DOF) vehicle simulations to characterize adverse conditions, failures, and loss-of-control Database & models validated in wind tunnel tests, Wind tunnel upgrade repair delayed test entry by 2 months.
Complete the development of flight crew knowledge and proficiency standards for automation	.	12/00	12/00	Complete	Documentation defining flight crew knowledge and proficiency standards for automation delivered to industry and academia.
Demonstrate in an operational environment, tools for merging heterogeneous databases to aid causal and risk assessment.	3/02	3/02	9/01		
Define an architecture for an integrated onboard health management system		9/01	9/01	Complete	A ground demonstration of the integrated onboard health management system concept, Aircraft Condition Analysis and Management Systems (ACAMS), was conducted in July 2001. In this demonstration intentional faults were injected into recorded flight data from the NASA B757 ARIES aircraft while running in real time simulation and processed through ACAMS. The ACAMS logic successfully identified the faults and provided an assessment of the impact on continued airworthiness prior to the conditions resulting in critical failure levels.
Evaluation of synthetic vision system (SVS) concepts in simulations and flight-tests		9/01	9/01	Complete	SVS display concepts, both in-house and industry-partner developed, intended for retrofit in commercial and business aircraft that were demonstrated in flight tests conducted in the terrain-challenged

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-03 Change	Comment
					environment of Eagle County Regional Airport, CO. during the period of August – September 2001
Identify concepts to reduce fuel system flammability		9/01	9/01	Complete	Three technical approaches were identified that offer promise of increasing the flash point temperature and thus decreasing the flammability of present day civil jet fuel while maintaining practicality and cost-effectiveness.
Complete the design criteria for low false-alarm fire detection systems		9/01	9/01	Complete	Validation of low false alarm fire detection design concepts was accomplished through testing and analytical modeling of cargo compartment fire signatures. Monitoring for non-smoke components of fire signatures, such as the build-up of CO and CO_2 gases, was shown to give the capability to reliably screen out false alarms.
Safety improvement concepts developed		9/01	9/01	Complete	The Aviation Safety Program has made significant technical progress and completed conceptual designs for its planned safety-improvement systems. This includes evaluation and documentation of a runway incursion prevention system concept, definition and documentation of weather information concepts for both GA and commercial operators, development and wide\ distribution of a cockpit automation textbook and a dual-volume icing hazards CD-ROM for pilot training, definition and baselined an architecture for onboard health management system, validated and documented a low false-alarm fire detection system concept, designed and applied performance monitoring concepts to Air Traffic Control system and documented user feedback.
Flight demonstration of forward-looking warning system	09/2002	06/2002	06/2002	+3 months	AvSP addressed skill and workforce shortages through a replanning activity that resulting in balancing of available resources
Demonstration of flight critical system validation methods	03/2003	06/2002	06/2002	+9 months	Delay in systems development due to contract negotiations
Computational models of present and future contexts	02/2003	06/2002	06/2002	+8 months	Complexity of the modeling work has caused the milestone to slip into FY 2003

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-03 Change	Comment
Interim integrated program assessment	06/2002	06/2002	06/2002		Internal assessment of programs toward goal achievement will be used to guide future investment decisions
National Aviation Operation Monitoring System (NAOMS) adds the general aviation (GA) pilot community to the survey system	06/2002	09/2002	09/2002	-3 months	Projected to complete early due to closer than expected cooperation from GA community
Demonstrate national capability for graphical display of weather information	09/2001	09/2002	09/2002	Complete	Near-term technology graphical weather displays for Transport and General Aviation (GA) aircraft were developed and demonstrated in flight under NASA Cooperative Research Agreements (CRA). Flight demonstrations included the following: United Airlines evaluated the Honeywell Weather Information Network transport system. Benefits demonstrated included turbulence mitigation. The Rockwell Enhanced Weather Radar system was evaluated on the NASA 757 research airplane, demonstrating the display of uplinked weather data combined with on-board radar data on a graphical weather information system. The display of weather products in a GA cockpit was demonstrated on a Cessna 180 using their Weather Hazard Information System developed under CRA. The impact of graphical weather on GA pilot decision-making was evaluated on the NASA B200 King Air research airplane using a tethered display developed by Honeywell under a separate CRA. Overall, collaboration between NASA and Industry through CRA's resulted in the technology readiness level for graphical weather display technologies to reach the target of TRL-6 one year earlier than originally planned.
Analysis tools for structural Crashworthiness predication	08/2002	09/2002	09/2002	-1 month	Projected to complete early due to software coding improvements.

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-03 Change	Comment
Demonstrate loss of control and Recovery models in high-fidelity 6-DOF simulation environment	09/2002	09/2002	09/2002		
Provide new software certification procedures intended for FAA incorporation into DO-178C	02/2003		02/2003		
Simulations and Flight Test Evaluations of Safety-Improvement Systems within AvSP Complete	03/2003		03/2003		
Integrated Synthetic Vision Systems Display Concepts Initial Flight Evaluation	03/2003		03/2003		
Demonstrate capability of fast-time simulation for reliable prediction and assessment of system-wide risk	03/2003		03/2003		
Initial Evaluation of Next-Generation Cockpit Weather Information and Digital Datalink Technologies.	06/2003		06/2003		
Smart Icing System (IS) – Ice Management System Demonstration	06/2003		06/2003		

Program Lead Center: Langley Research Center	**Other Centers:** Glenn Research Center, Ames Research Center, Dryden flight Research Center, Goddard Space Flight Center	**Interdependencies:** FAA
Project	**Project Lead Center**	**Industry Contractor (Location)**
Vehicle Safety Technologies	Langley Research Center	Rockwell, BAE Systems, Research Triangle Institute, Jeppensen, AVROTEC, Lockheed Martin, ARINC, Honeywell, Delta Airlines
Weather Safety Technologies	Glenn Research Center	Honeywell, Rockwell, ARNAV, NCAR, FAA
System Safety Technologies	Ames Research Center	San Jose State University, New York University, Raytheon, Boeing, University of Idaho, Battelle Memorial

		Institute,
Program Product	**Builder (Location)**	**Product Benefit**
Aviation Weather Information System	Multi-contractor effort	Demonstrate and deliver at least 2 operational graphical weather products available via VHF broadcast over CONUS at 5000 ft or greater altitude, projected to reduce fatal weather-induced accidents by 25% (GA – 50%)
Turbulence Predication and Warning System	Multi-contractor effort	Demonstrate and deliver certifiable detection products providing at least 30 seconds advanced warning of severe turbulence, projected to reduce turbulence injuries by 25%
Synthetic Vision Display System	Multi-contractor effort	Demonstrate and deliver certifiable synthetic vision technologies with wire-frame displays and terrain resolution of 100m for enroute operations, projected to reduce commercial Controlled Flight Into Terrain fatal accidents by 50%
Precision Approach and Landing and Display System	Multi-contractor effort	Demonstrate and deliver certifiable precision approach and landing technologies highlighting the selected runway and ground-identified potential conflicts, projected to reduce the number of runway incursion fatal accidents by 50%.
Human Error Assessment Methodologies	Multi-contractor effort	Demonstrate improved training modules, maintenance procedures, and system design assessment methodologies, projected to reduce citing of human error as a causal factor in commercial aviation accident reports by 5% (
Health and Usage Monitoring Technologies	Multi-contractor effort	Demonstrate and deliver certifiable Health and Usage Monitoring technologies for commercial transport aircraft, projected to reduce failed equipment-citings in fatal accident reports by 5%
Advanced structural and material designs	Multi-contractor effort	Demonstrate and deliver advanced structures, materials, and system designs, projected to improve crash survivability and fire hazard mitigation in fatal accidents by 10%

Integrated Aviation System monitoring tools and Infrastructure design	Multi-contractor effort	System tools operational with at least two major air carriers and at least one corporate air service provider by 2004 This will provide the companies with an advance warning of potential safety problems and adverse trends and suggest corrective actions.

PROGRAM STATUS/PLANS THROUGH 2002

The program is successfully demonstrating component technologies that will lead to system demonstrations as well as downselects to the “best” concepts. In FY01 the program developed safety-improvement concept designs for all projects within the program. The following research and technology efforts were completed: evaluated and documented runway incursion prevention system concepts; defined and documented weather information concepts for both general aviation and commercial operators; developed and widely distributed a cockpit automation textbook and a dual-volume icing hazards CD-ROM for pilot training (distribution for both products included flight schools and major air carriers); defined and baseline architecture for onboard health management system; validated and documented low false-alarm fire detection system concepts; and designed and applied performance monitoring concepts to the Air Traffic Control system.

In FY 2002 the program will conduct an interim integrated program assessment in which the program will be reassessed against technical risk, safety benefit, implementation schedule, cost and return-on-investment (ROI), and a projection will be made as to the impact upon the reduction of the fatal accident rate. The following research and technology efforts will be completed in FY 2002: develop simulation models and subsystem concepts for loss-of-control prevention and recovery in a simulation environment; flight demonstration of a forward-looking onboard turbulence warning system that results in an advance warning of 30 seconds or better, for a significant portion of hazardous turbulence; demonstrate, in an operational environment, tools for merging heterogeneous databases to aid causal analysis and risk assessment; add general aviation pilot community to the National Aviation System Operational Monitoring Service (NAOMS) survey system; perform initial verifications, through analytical modeling and limited impact testing of aircraft components, of occupant crash load estimation methods for use by the FAA and industry.

PROGRAM PLANS FOR FY 2003

NASA will work with, and rely on, industry and FAA partners to Demonstrate or evaluate eight safety-improvement systems including: flight evaluation by airline and test pilot of synthetic vision system (SVS) products integrated with precision approach and landing and display system concepts intended for commercial and business aircraft; initial flight evaluation of a next-generation cockpit weather information digital datalink and turbulence system for increasing situation awareness and decision making tools; demonstration of a smart icing management system for automatic management of ice protection systems; demonstration of a vehicle health management system lab; demonstration of disturbance recovery methods for flight critical systems; demonstration of an engine disk crack detection monitoring system in the relevant environment; demonstration of a fast-time simulation for reliable prediction of system-wide risk.

BASIS OF FY 2003 FUNDING REQUIREMENT

VEHICLE SYSTEMS PROGRAM

Web Address: http://www.aero-space.nasa.gov/programs/vs.htm

	FY 2001	FY 2002	FY 2003
		(Millions of Dollars)	
Vehicle Systems Program	**370.8**	**369.4**	**321.3**
Quiet Aircraft Technology (QAT)	19.9	20.0	20.0
21st Century Aircraft Technology (TCAT)	6.7	29.0	29.0
Ultra-Efficient Engine Technology (UEET)	47.9	50.0	50.0
Propulsion & Power	79.7	92.4	66.8
Flight Research	59.8	52.5	58.9
Advanced Vehicle Concepts	61.2	42.3	34.7
Breakthrough Vehicle Technologies	84.4	83.2	61.9
Minority University Research and Education Program	11.2	--	--

DESCRIPTION/JUSTIFICATION

Over the last century, aviation has evolved to become an integral part of our economy, a cornerstone of our national defense, and an essential component of our way of life. Aviation generates more than $1 trillion of economic activity in the United States every year. Military aviation forms the backbone of the U.S. security strategy. All military services (Air Force, Navy, Army, and Marines) possess aviation capability, and nearly a third of the Defense Department's budget relates to aviation activities. Americans per capita use aviation more than any other country in the world. Today personal travel accounts for more than 50 percent of commercial air transportation, and the percentage of people who have flown increases at an average of 2 percent per year.

As the nation and the world become more dependent on moving goods and people faster and more efficiently by air, important and difficult challenges have emerged. Saturation of the civilian air transportation system is causing delays and disruptions in air service. Military challenges have become more complex. The fight against international terrorism has replaced the Cold War. As a result, our military strategy has shifted from the traditional "threat-based" defense planning of the past to a "capabilities-based" model in the future.

Advances in technology have paced aviation's evolution throughout its first century. Human ingenuity once the only bounds to growth in aviation, have produced a highly complex, integrated, and regulated aviation system. To move aviation ahead in the next century, we will need to capitalize on the convergence of a broad front of multidisciplinary advances in technology. Advances in information technologies are already enabling major changes in aviation. Aviation materials have improved dramatically over the last century; the coming revolution in nanotechnologies promises to accelerate that progress. Likewise, biological sciences are providing a new way to look at machines. Mimicking nature will enhance flight safety and result in more reliable air vehicles.

In FY 2001, the Aerospace Technology Enterprise developed a blueprint for aeronautics for the 21st century. The blueprint describes a vision of the revolutionary technology advances that could change aviation. It does so with the understanding that the combined efforts of NASA, the Departments of Defense (DoD) and Transportation (DoT), the FAA, academia and industry will be needed to realize the vision. The technology advances discussed will help solve today's impending crises and create a new level of performance and capability in aviation. They are targeted to produce:

- Advanced concepts for the Airspace System,
- Revolutionary vehicles with significantly greater performance,
- New paradigms for aviation security and safety, and
- Assured development of a capable engineering workforce for the future.

U. S. competitors are targeting aviation leadership as a stated strategic goal. Without careful planning and investment in new technologies, near- term gridlock, constrained mobility, unrealized economic growth, and the continued erosion of U. S. aviation leadership could result.

The Vehicle Systems Program is organized into seven program areas to develop new aircraft vehicle technologies in support of the aeronautics blueprint: Breakthrough Vehicle Technologies, Propulsion & Power, Flight Research, Ultra-Efficient Engine Technology, Quiet Aircraft Technology, 21st Century Aircraft Technology, and Advanced Vehicle Concepts.

Breakthrough Vehicle Technologies investigates and develops breakthrough technologies to maintain the superiority of U.S. aircraft, to ensure the long-term environmental compatibility of aircraft systems, and to improve their safety and efficiency. Deliverables are technologies for various vehicle components and sub-systems, such as new ultra-light weight materials; computational models and design tools; and smart sensors and actuator systems. Technology will be demonstrated in a laboratory environment to show the feasibility of a research approach and evaluation by independent peer review. Technology demonstration and peer evaluation are the foundation to manage the vehicle technology investment portfolio and determine whether a given technology warrants further maturation. These breakthrough technologies will feed other NASA aviation programs like Aviation Safety, Quiet Aircraft Technology, and 21st Century Aircraft Technology.

The objectives of **Propulsion & Power** are to investigate and develop breakthrough technologies to maintain the superiority of U.S. engines, to ensure the long-term environmental compatibility of engine systems, and to improve their safety and efficiency. Deliverables are technologies for various engine components and sub-systems, such as new combustor concepts, new materials for high temperature applications, or new engine concepts. Technology will be demonstrated in a laboratory environment to show the feasibility of a research approach- and evaluated by independent peer review. The technology demonstration and peer evaluation are the foundation to manage the propulsion technology investment portfolio and determine whether a given technology warrants further maturation. These technologies will feed other NASA aviation programs including Aviation Safety, Ultra Efficient Engine Technology, Quiet Aircraft Technology, and 21st Century Aircraft Technology.

The objectives of **Flight Research** are to safely conduct, enable, and improve NASA's atmospheric flight research capability. It promotes technology innovation, discovers new phenomena, and accelerates development of new aerospace concepts. Concept input to the project may come from the other Vehicle Systems program projects, industry, academia, or DoD. Technology is demonstrated to show the feasibility of a technology concept in a relevant (flight) environment.

The primary objective of **Ultra-Efficient Engine Technology** is to address two of the most critical aviation propulsion issues: performance-efficiency and reduced emissions. High performance, low emissions engine systems will lead to significant improvement in local air quality, minimum impact on ozone depletion, and an overall reduction in aviation impact on global climate change.

The goal of **Quiet Aircraft Technology** (QAT) is to develop technology that, when implemented, reduces the impact of aircraft noise to benefit airport neighbors, the aviation industry, and travelers. QAT will directly improve the quality of life of our citizens by reducing their exposure to aircraft noise, thereby eliminating constraints on the air transportation system.

Twenty First Century Aircraft Technology (TCAT) is a next step in reaching the long-term aspect of the Revolutionize Aviation Goal of enabling the development of an environmentally friendly global air transportation system with unquestionable and higher levels of safety that improves the Nation's mobility during the next century. The technologies developed in TCAT and the concepts enabled by these technologies will impact all of the objectives of the goal, particularly the emissions objective. The TCAT Project will utilize systems analysis to quantify potential project benefits and to guide future project investment decisions.

The goal of **Advanced Vehicle Concepts** (AVC) is to accelerate the development and maturation of advanced and innovative vehicle concepts and technologies using system level integration, ground demonstration and flight validation testing. Flight-testing of new vehicle concepts and technologies is required to validate system concepts in a relevant flight environment and accelerates technology insertion into commercial and military applications. The AVC approach is to execute a continuing series of cost effective, high-technical-risk flight demonstration and validation experiments, and research using modularized, subscale flight demonstrators. For example, the Hyper-X goal is, for the first time ever, to fly the X–43A supersonic combustion ramjet-powered aircraft at its Mach 7 and 10 test points to validate hypersonic design and analysis tools and ground facility capabilities. This will provide the Nation with a new high-speed propulsion system for space launch or military aviation applications. The demonstrations will use either subscale flight demonstrators (such as unpiloted, ground controlled vehicles), modifications to existing flight test aircraft, or all new aeronautical vehicles to achieve the AVC technology outcomes.

OBJECTIVE:	**PROGRAM APPROACH:**
Revolutionize Aviation □ Increase Safety □ Reduce Emissions □ Reduce Noise □ Expand Aviation Capacity □ Improve Mobility	The program integrates all aircraft vehicle technology efforts. It consists of a balance of mid- and far-term technology development activities. Three projects—Breakthrough Vehicle Technologies, Propulsion & Power and Flight Research—develop the fundamental technologies needed to enable new functionality in 21st century aircraft. Three projects—Ultra-Efficient Engine Technology, Quiet Aircraft Technology and 21st Century Aircraft Technology—focus on the maturation and integration of these

	technologies into subsystems and systems that can be developed with industry partners into high leverage products. The Advanced Vehicle Concepts project takes those vehicle and technology concepts which require flight testing through additional systems analysis, concept development and flight testing.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Revolutionize Aviation
Strategic Plan Objectives Supported: Increase Safety, Reduce Emissions, Reduce Noise, Expand Aviation Capacity, Improve Mobility
Performance Plan Metrics Supported: APG 3R1

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-03 Change	Comment
Vehicle Systems Program Develop a program roadmap of an integrated vehicle systems contribution to the 25-year revolutionize aviation goal.	10/02	N/A	10/02		
Based on demos and tests of emerging technologies (e.g., morphing, carbon nanotube fabrication), assess progress to ensure performance relevance against program objectives.	9/03		9/03		
Conduct an interim assessment of the potential noise and emissions reductions enabled by the mid-term airframe and engine technologies.	9/03		9/03		
Conduct a series of flight experiments to provide initial validation for rapid technology insertion into military and commercial aircraft.	9/03		9/03		
Evaluate combustor sector configurations for 70 percent reduction of oxides of nitrogen (NOx) during landing and take-off.	9/03		9/03		

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-03 Change	Comment
Demonstrate a prototype electric powered UAV capable of sustaining 14 hrs of operation above an altitude of 50,000 ft with a UAV that has growth potential for extreme duration of greater than 96 hours.	9/03		9/03		Fourteen hours is more than double that duration about 50,000 ft that has currently being achieved with electric aircraft. With the technology challenges still being resolved with the closed-cycle regenerative fuel cells, we have decided to go with primary hydrogen fuel cells for the flight test. This decision is in concert with the industry interests in UAV extreme duration technology. Further, the FY 2002 milestone, "*Complete development of laboratory (heavy weight) energy storage*" has demonstrated the initial 96-hour test.
Develop initial physics-based noise prediction models	9/03		9/03		
Breakthrough Vehicle Technologies					
Envelope expansion of Airframe Integrated, Dual-Mode Scramjet powered vehicle in flight at Mach 7.		6/01	12/00	Flight Failure	During its first flight, the launch vehicle for the X-43A hypersonic test vehicle experienced a failure, deviated from its flight path and was deliberately terminated. The planned follow-on flight program has been suspended pending the results of the Mishap Investigation Board, which are to be released in early CY 2002.
Complete systems analysis of STOL and ESTOL studies to understand the benefits of these vehicles to the small transportation system.			6/01	Deleted	Deleted in FY01 in favor of higher priority activities
Obtain wind-tunnel performance data of hingeless control surfaces on a full-span 30% geometric scale "smart" uninhabited combat air vehicle (UCAV) model		9/01	9/01	Complete	Test in TDT completed and objective achieved.
Demonstrate an airframe integrated, dual-mode scramjet powered vehicle in flight at Mach 10	TBD	6/02	9/01	TBD	The flight test date is to be determined until the Mishap Investigation Board releases its report in early CY 2002.
Real-time piloted simulation validation of the reconfiguration intelligence component of central nervous system		6/01	3/01	Complete	Validated the reconfiguration intelligence component via real-time simulation

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-03 Change	Comment
Protocols and Test Methods Needed For Accelerated Testing of Space Transportation		3/01	3/01	Complete	Initial protocols for accelerated test methods developed. Protocols provide guidelines for systematically establishing degradation mechanisms and damage modes associated with long-term exposure of polymeric composites to mechanical load, elevated temperature, moisture and oxygen
Demonstrate an Airframe Integrated, Dual-Mode Scramjet powered vehicle in flight at Mach 7.	TBD	12/01	6/01	TBD	The flight test date is to be determined until the Mishap Investigation Board releases its report in early CY 2002.
Identify approaches for fabrication of structures inspired by biology.		9/01	6/01	Complete	Successfully demonstrated free form fabrication that allows achievability of ultra-lightweight structural components.
Complete National Transonic Facility (NTF) testing of 777 baseline cruise wing configuration and NTF/computational fluid dynamic (CFD)/ flight assessment of cruise condition.		9/01	9/01	Complete	Data obtained for use in ground to flight scaling.
Validate developed noise reduction technology at large scale to reduce technical risk of future technology implementation.		9/01	9/01	Complete	Successfully validated large-scale noise reduction by 4098 static engine test, STAR 40 x 80 test, Falcon/Lear flight test, interior noise tone reduction flight test and laboratory assessment.
Complete integrated system flight and simulation testing of Advanced General Aviation Technology Experiment (AGATE) Highway in the Sky (HITS) operating capability, DIF system, and simplified flight controls.		9/01	9/01	Complete	Final closeout reports have been delivered. Plans for use of DIF underway in Small Aircraft Transportation System and AWIN.
Publish design guidelines, system standards, certification bases and methods to document lessons learned in the AGATE project.	12/01	9/01	9/01	+3 months	Final closeout reports received. Distribution and archival of reports on schedule for completion by 12/01.
First demonstration of flow control via oscillatory blowing with leading and trailing edge actuators to enable simplified high-lift systems for high aspect ratio wings.	3/02	3/02	3/02		
Capability developed & demonstrated for viscous, solution-adaptive system using high-fidelity modeling, generating an unstructured-grid CFD from a geometry model for a complex aerospace vehicle in 1 day.	6/02	6/02	6/02		

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-03 Change	Comment
Demonstrate the feasibility of fabricating carbon nanotubes in an aligned configuration	9/02	9/02	9/02		
Demonstrate adhesives for non-autoclave composite processing.	9/02	9/02	9/02		
Propulsion and Power					
Complete inlet test for pulse detonation engine Flight Research project		5/01	5/01	Deleted	Independent review team recommended no flight test at this time.
Downselect of ground-based remote sensor technologies for a prototype ground-based system to sense icing conditions.		6/01	6/01	Complete	Assessment resulted in the selection of a ground-based icing remote sensing system to be further developed.
Demonstrate viability of hot section foil bearing		8/01	8/01	Complete	Bearings tested through range of high-speed, sustained load, and elevated-temperature conditions.
Demonstrate the durability of cast Titanium-Aluminum (crack resistant blades) for Low-Pressure Turbine (LPT) applications		9/01	9/01	Complete	Six factors were evaluated. Cast g-TiAl LPT blades are expected to survive domestic object damage observed during normal engine operating conditions.
CD-ROM icing pilot training module	6/02	6/02	6/02		
Demonstrate reaction transfer molded polymer matrix composite with 550 °F use temperature.	9/03	9/02	9/02	+12 months	Milestone slip due to Enterprise-level adjustments in priority activities between Propulsion and Power and Advanced Space Transportation Programs.
Conduct spin and burst tests to evaluate the effect of dual microstructure heat treatment processing technology on disk life	9/02	9/02	9/02		Milestone wording was changed from FY2002 Narrative ("*Mature UltraSafe propulsion technologies transferred to Aviation Safety Project*") to more clearly indicate specific advanced technology to be transferred to Aviation Safety Program.
Mature UltraSafe propulsion technologies transferred to Aviation Safety program	9/02	9/02	9/02		
Engine test a coated polymer matrix composite inlet guide vane	9/03	9/02	9/02	-12 months	Milestone moved forward due to anticipated benefits and potential collaborations with industry partner.
Assess hybrid fuel cell and liquid hydrogen fueled optimized turbofan concepts	9/02	9/02	9/02		Issue a report on conceptual application of LH2 propulsion concepts to subsonic transport aircraft, including propulsion system and airframe concepts characterizations complete with mission emission characterizations.

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-03 Change	Comment
Demonstrate concepts for reduction in gaseous, particulate, and aerosol emissions	9/02	9/02	9/02		Demonstrate revolutionary fuel injector concepts in flame tube tests. Concepts will utilize advanced technology, including ceramics, MEMS technology, and active control aimed at achieving 80% NOx reduction goal, and reducing particulate and aerosol emissions.
Downselect Pulse Detonation Engine-based propulsion concept(s) for system or critical sub-system experimental demonstration based on PDET conceptual design and component research activities	9/02	9/02	9/02		Milestone adjusted from FY2002 Narrative to more accurately account for technical challenges uncovered in early systems analyses and research phases of the project. Technology area remains high potential for revolutionary advances in propulsion.
Revolutionary aerospace propulsion concepts identified and preliminary performance assessed.	9/02	9/02	9/02		
Flight Research					
Demonstrate functionality of autonomous station keeping for a two aircraft formation.		3/01	3/01	Complete	The trailing aircraft maintained autonomous formation control in the lateral and vertical axes to within 5 feet of the commanded position.
Complete development of laboratory (heavy weight) energy storage	1/02	9/01	9/01	+4 months	Electrolyzer, fuel cells, and control system delivered. Integration and testing should be complete by end of January.
Demonstrate solar power remotely piloted aircraft flight to 100,000 feet		9/01	9/01	Complete	The Helios aircraft completed a record-breaking flight that established the altitude record for sustained level flight at 96,833 feet.
Complete development, validation, and flight-testing of a differential carrier-phase Global Positioning System receiver coupled with an Inertial Measurement Unit using a Kalman filter.	10/01	9/01	9/01	Complete	Maintained control performance to less than ±5 feet.
Demonstrate robust taxi capability with contingency planning for an autonomous vehicle (UCAV).	10/01	9/01	9/01	Complete	Demonstrated autonomous taxi control algorithms.
Demonstrate turbo-prop, remotely piloted aircraft capabilities that exceed the minimum Earth Science altitude and duration requirements.	9/02	9/02	9/02		

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-03 Change	Comment
Utilize DFRC's core flight research capabilities by using the specially configured F-15 B testbed aircraft to provide NASA, industry and academia with flight research opportunities. Complete at least 4 flight experiments on the F-15B. Experiments currently being considered for FY 2002 include the Propulsion Flight Test Fixture (PFTF), Airborne Schlieren Imaging, Supersonic Natural Laminar Flow II, an Axisymmetric Rocket Based Combined Cycle (RBBC) experiment, and a supersonic high-mass flow inlet.	9/02	9/02	9/02		
Twenty First Century Aircraft Technology					
Demonstrate a methodology for scaling laws to validate the Reynolds number for on-set of aerodynamic flow separation.	3/02	3/02	3/02		
Demonstrate the ability to dynamically alter the localized flow instabilities over advanced lifting surfaces with micro-adaptive flow control devices.	6/02	6/02	6/02		
Develop concepts for design and analyses of algorithms for control of colonies of fluidic flow control effectors.	6/02	6/02	6/02		
Develop concepts and analyses of advanced composites including nanotube reinforced polymers to characterize processing uncertainties on material properties	9/02	9/02	9/02		
Conduct electromagnetic impact assessment on critical flight control hardware through physics-based modeling of the electromagnetic field.	9/02	9/02	9/02		

Quiet Aircraft Technology					
Discovery and initial assessment of concepts to achieve 3 dBA airplane system noise reduction		9/01	9/01		Defined the technology baseline against which program progress will be measured by assessing the outcome of the previous Noise Reduction program. Deferred the initial assessment of new technology concepts to focus attention on the technology baseline and foundation for discoveries. The remaining portion of this milestone will subsumed in the effort to determine the technologies required to meet the 10 dBA noise reduction goal (FY 2002 milestone - 3/02)
Identify community noise impact reduction technology required to meet 10-year, 10 dBA Enterprise goal	3/02	3/02	3/02		
Ultra-Efficient Engine Technology					
Propulsion-Airframe Integration: Prediction of propulsion-airframe integration (PAI)		9/01	9/01	Complete	An advanced PAI concept, boundary layer ingestion nacelles integrated to the Blended Wing Body (BWB), will be fabricated as a wind tunnel model and tested in the NTF in FY 2003 to validate the design study at Mach 0.85 and near-flight Reynolds number.
Turbomachinery: Flow control concepts for advanced propulsion systems		9/01	9/01	Complete	Hardware to evaluate the concept selected for Low Pressure Turbine (LPT) flow control will be fabricated and rig tested. This test, which should occur in the FY 2004-2006 time period.
Integration and assessment: definition of advanced propulsion options		9/01	9/01	Complete	The study results and system concepts will be updated and modified as appropriate as baselines to be used to assess overall impact of the individual propulsion technologies.
Materials and Structures: High temperature turbomachinery disk alloy		9/01	9/01	Complete	This completed NASA's immediate efforts to develop and transition to industry a revolutionary turbomachinery disk material.
Integrated Component Technology Validation: Aspirating seal demonstration	3/02	3/02	3/02		
Integrated Component Technology Validation: Integrated component technology demonstrations plan	4/02	4/02	4/02		

Emissions Reduction: Initial low NOx combustor sector test	9/02	9/02	9/02		
Materials and Structures: Ceramic thermal barrier coating system	9/02	9/02	9/02		
Materials and Structures: Ceramics Metrics Composites complex part demonstrated in rig test		12/02	12/02	Deleted	This was deleted to enable the addition of revolutionary work such as the 3000°F CMC material system and the single crystal Nickel-based alloy computational tools development.
Advanced Vehicle Concepts					
Complete Blended Wing Body (BWB) Critical Design Review			6/01	Deleted	Deleted in favor of higher priority activities
IFCS (C-17) – Integration and demonstration of Intelligent Flight Control (IFC) into a C-17 simulation.	3/02	3/02	3/02		
IFCS (F-15) – Risk Reduction Flight Test	6/02	6/02	6/02		

Lead Center: Headquarters	**Other Centers:** Ames Research Center, Dryden Flight Research Center, Glenn Research Center, Langley Research Center	**Interdependencies:** FAA
Projects	**Lead Center**	**Major Contractors / Partners**
Breakthrough Vehicle Technologies	Langley Research Center	Luna Innovation, Blue Road Research, Lockheed Martin, Sciaky. General Electric, Northrup, Grumman, Boeing, Integral Wave Technology, Department of Defense (DoD), NIST, Oak Ridge National Labs, Sandia National Labs
Propulsion and Power	Glenn Research Center	Williams International, Allison Advanced Development Corp., General Electric Aircraft Engines, Pratt & Whitney, Boeing, United Technologies, Honeywell, Multiple universities, DoD
Flight Research	Dryden Flight Research Center	DoD
Ultra-Efficient Engine Technology	Glenn Research Center	Williams International, Allison Advanced Development Corp., General Electric Aircraft Engines, Pratt & Whitney, Boeing, Honeywell, Lockheed Martin, Georgia Tech, DoD
Quiet Aircraft Technology	Langley Research Center	Raytheon Aircraft Company, Rolls Royce, Pratt & Witney, Boeing, Delta Airlines, Honeywell, Cessna Aircraft. Lockheed Martin, FAA, DoD, DOT

Twenty-First Century Aircraft Technology	Langley Research Center	Boeing, Honeywell, Lightning Technologies Inc., Nielson Engineering, WILCO International, M-Dot Aerospace Gellman Research Associates, Los Alamos Labs, NCARR, DoD, FAA
Advanced Vehicle Concepts	Langley Research Center	Boeing, Lockheed Martin, Pratt & Whitney, Sikorsky, DoD, Australia Aeronautical and Maritime Research Lab.

Program Product	**Builder (Location)**	**Product Benefit**
In-depth scientific understanding of a set of emerging aircraft technologies	Multiple Contractors	Most promising emerging aircraft technologies identified for further maturation to support the Revolutionize Aviation objectives of increasing safety, reducing environmental impact, and increasing mobility.
Flight test new vehicle concepts.	Multiple Contractors	Validated performance of new aircraft technologies to accelerate insertion into, and hence their benefits in commercial and military applications.
Noise reduction technologies validated through subscale testing and simulations.	Multiple Contractors	Technologies ready for further maturation to reduce community noise impact by 5 dB by 2005 and investigate technologies and vehicle concepts for the next 10 dB reduction.
Emission reduction technologies validated in ground tests.	Multiple Contractors	Technologies transferred to industry to enable 70% reduction in NOx emissions and 25% reduction in CO_2 emissions.
Advanced vehicle and propulsion concepts and technologies demonstrated in laboratory environment.	Multiple Contractors	Technologies and concepts identified for further maturation and risk reduction to expand the future capability of the aviation system with safe, affordable and direct service to all of America's communities.

PROGRAM STATUS/NOTIFICATIONS/PLANS THROUGH 2002

In FY 2001, the **Aerospace Vehicle System** Technology program successfully completed the large-scale validation of noise reduction technologies and the flight-testing of the general aviation system concepts, leading to a smaller noise-footprint at the airport. The completion of these tests concludes the noise reduction and general aviation projects that were begun as part of the Advanced Subsonic Technology Program. Identification of protocols and methodologies for accelerated testing of space transportation materials was completed. A key workshop was held in 2001 to assess the state of turbulence research and determine future research needs to accurately predict aerodynamic flow and noise generation. Also, tests were completed to provide a benchmark to the National Transonic Facility for ground-to-flight scaling on a cruise wing configuration of a transport aircraft. The annual OAT goals assessment was completed to understand progress toward Enterprise goals. Hingeless control surfaces were evaluated in wind tunnel testing. Systems analysis was begun on personal air vehicle concepts to understand benefits of these vehicles to the small transportation system. Real-time piloted simulation validation was completed to determine potential viability of a vehicle central nervous system, one of the first stages of a warping-wing to create a bird-like aircraft. Free-form ultra-lightweight structural component fabrication was demonstrated: The first-order material/structural properties of carbon-nanotube-based materials was characterized, an important first step to enable simulation tools that accurately predicts performance. The design of a prototype carbon nanotube electromagnetic field sensor that will use less power than current sensor technology was completed. The program developed a thin-film polymer actuator for shape control of membrane structures. Analysis tools for film-based and gossamer structures were validated via testing of a variety of components. These tools required development of test and measurement techniques. Development of an expert tool that provided efficient, rapid and highly reliable selection of space-capable materials that meet the requirements of specific engineering applications will be completed.

In FY2001, the **Hyper-X (X-43A)** sustained a boost failure on the first flight (planned for Mach 7) in June 2001. A mishap investigation was formed and its findings were reported in early CY 2002. In addition to continuing work on vehicles two and three, the program also supported the work related to determining the cause of the booster mishap including a major series of wind tunnel tests in late FY 2001 and early FY 2002.

For the **Propulsion and Power** Program, during FY2001, work was completed on the durability of cast Titanium Aluminum (TiAl) low pressure turbine blades for engine safety improvement. Additionally, foil bearings, which will enable oil-free turbine engines, were tested in a core engine section. Results indicate that the foil bearings can withstand conditions in excess of expected engine operating conditions. Oil-free turbomachinery technology could lead to simpler, easier to maintain engines. Additionally, significant progress was made in the area of zero CO_2 emissions research by testing a hydrogen-fueled gas turbine engine and a fuel-cell-based propulsion system. Significant advances were made in reducing the permeability of lightweight polymer-composite, liquid-hydrogen tanks for safe and efficient storage of low-density liquid hydrogen and in determining the fracture toughness of solid oxide fuel cell electrolytes for high-pressure hydrogen/air fuel cells. The Aircraft Icing project made significant contributions to alleviation of aircraft icing hazards. The project assessed the potential for a ground-based icing sensor system and proceeded with down-selecting a system for further development. Also, nanotechnologies, as applied to the harsh operating environments encountered in turbine engine systems, were investigated. During FY2002, Propulsion and Power will continue to work on controlling combustion instability in engines, thus enabling lower emissions operations. Revolutionary fuel injector concepts that utilize advanced technology, including ceramics, MEMS, and active combustion control aimed at reducing NOx emissions by 80% and to further reducing particulate and aerosol emissions will be demonstrated. The fundamental aspects of noise generation and propagation and the identification of advanced noise reduction concepts will continue. This activity will provide enabling capabilities for new, high-risk, high-payoff technologies that are of long term strategic importance in noise reduction. An assessment of hybrid fuel cells and liquid hydrogen-optimized turbofan concepts will be completed; pointing the way toward feasible concepts for further development for reducing or eliminating CO_2 emissions. Identification and preliminary performance assessment of revolutionary aeropropulsion concepts and technologies will be completed. In addition, we will establish two Research, Education, and Training Institutes (RETIs) in propulsion and power research. To ensure the highest quality research and training and infusion of new ideas, these RETIs will be subject independent, external reviews with recompetition at regular intervals, including mandatory sunsets after ten years.

In FY2001, **Flight Research** the Environmental Research Aircraft and Sensor Technology (ERAST) project conducted record-breaking flights of the Helios aircraft, a 247-foot wingspan aircraft, to an altitude of 96,833-feet. Flight Research also initiated C-17 testbed experiments, continued F-15B testbed experiments and made significant advancements in Autonomous Formation Flight (AFF) research activities in FY 2001. Fiscal Year 2002 promises to be a productive year of flight research. In ERAST, Flight Research will demonstrate a turbo-prop UAV capability that exceeds the minimum Earth Science altitude (40,000') and duration (24 hour) requirements. Flight testbed activities this year may include: PFTF Envelope Expansion, Airborne Schlieren Imaging, Supersonic Natural Laminar Flow II, and Axisymmetric Rocket Based Combined Cycle experiments. This fiscal year the Intelligent Flight Control Systems (IFCS) activities will begin in earnest – the integration and demonstration of IFCS into a C-17 simulation will transfer the F-15 IFC software into a transport configuration, validating IFC technology in a transport type aircraft simulator. The F-15 IFCS activity will initiate risk reduction flight test. In pursuit of efficiency and affordability an F-18 testbed aircraft will continue its modification and systems checkout in preparation of FY 2003 flights to investigate Active Aeroelastic Wing (AAW) technology. The Autonomous Formation Flight (AFF) activities in FY 2002 will demonstrate drag reduction and substantial fuel savings as a result of coordinated autonomous aircraft operations.

In FY 2001, the **Ultra Efficient Engine Technology** Program completed work on a new disk alloy that will advance the state of the art for commercial and military airplane turbine engines. The new alloy, a nickel-based powder metallurgy superalloy, can withstand temperatures over 1300 degrees F, a 150-degree increase over disks currently in operation. With the increase in operability at high temperatures, engines can function at higher-pressure ratios than current engines, translating into increased fuel efficiency and lower fuel burn resulting in reduced aircraft emissions. In addition, the disk alloy is estimated to be able to operate 30 times longer than current disks, resulting in increased time between required maintenance In FY 2002 the Ultra Efficient Engine Technology Program continued to evaluate promising propulsion technology approaches for emissions reduction (NO_x and CO_2) through laboratory tests, computational simulation evaluations, and in two cases integrated component technology demonstrations in partnership with industry. Specifically engine testbed demonstrations (TRL6) of a 200 deg F ceramic matrix composite (CMC) combustor liner and a low-pressure turbine aspirating seal concept were conducted in partnership with General Electric Aircraft Engines. Initial combustor sector tests (TRL4) of ultra low emissions approaches were conducted with four of the major partners (GE, Pratt & Whitney, Allison, and Honeywell). These initial test results will provide insight into the most attractive approaches to pursue to reach the program goal of 70% landing/takeoff (LTO) NO_x reduction. (In each case the industrial partner in kind contribution at least equaled the NASA research investment.)

In FY 2001 **Quiet Aircraft Technology** defined the technology baseline against which program progress will be measured by assessing the outcome of the previous Noise Reduction program. In FY 2002 Quiet Aircraft Technology will develop technology that, when implemented, reduces the impact of aircraft noise to benefit airport neighbors, the aviation industry, and travelers. The QAT Project will directly improve the quality of life of our citizens by reducing their exposure to aircraft noise, thereby eliminating constraints on the air transportation system. The QAT Project goals are to develop and laboratory-validate physics-based noise prediction models; use the physics-based codes to discover and develop laboratory-validated technologies necessary (but not sufficient) to achieve the Enterprise 10-year, 10 dB objective; and develop a framework using the physics-based noise prediction codes to initially identify technologies necessary to meet the 25-year, 20dB Enterprise objective. Specifically in FY 2002 the project will complete a system study to identify the community noise impact technologies required to meet the 10-year, 10 dB Enterprise Goal

In FY 2002, **Breakthrough Vehicle Technologies** will complete annual OAT goals assessment and system studies of several revolutionary concepts will be completed. The first demonstration of open loop flow control via oscillatory blowing with leading and trailing edge actuators to enable simplified high-lift systems will be completed. Demonstrations of a viscous solution adaptive system using high fidelity modeling and generating an unstructured grid CFD mesh and solution from a CAD model in one-day will also be completed. To increase structural efficiency of polymer matrix materials, candidate processes for fabricating aligned carbon nanotubes reinforced polymer fibers will be evaluated. Concepts for advanced sensory materials and for embedding sensors into aerospace structural materials will be developed. Finally, BVT will establish a University Research, Education, and Training Institutes (URETI) in Materials and Structures research. To ensure the highest quality research and training and infusion of new ideas, this URETI will be subject independent, external reviews and recompetition at regular intervals, including a mandatory sunsets after ten years.

In FY 2002 **Twenty-First Century Aircraft Technologies** will focus on the development of the following technologies: Demonstrate the methodology to produce scaling laws to validate the Reynolds's number for on-set of aerodynamic flow separation. Demonstrate the ability to dynamically alter the local flow instabilities over advanced lifting surfaces with micro-adaptive flow control devices. Develop concepts for design and analysis of algorithms for control of colonies of fluidic flow control effectors. Develop concepts of nondeterministic analysis of advanced composites including nanotube-reinforced polymers to characterize processing uncertainties of material properties. Conduct electromagnetic impact assessment on critical flight control hardware through physics based modeling of the electromagnetic field.

In FY 2002, **Advanced Vehicle Concepts** will focus on the following specific activities: Fabricate and test proof of concept Blended Wing Body wing to validate design and fabrication process. Integrate and demonstrate Intelligent Flight Control in a C-17 simulation. The demonstration of IFCS in a C-17 simulation will transfer the F-15 IFC software into a transport configuration, validating IFC technology in a transport type aircraft simulator. Additional FY 2002 activities in the **Hyper-X (X-43A)** program include accomplishing all required return-to-flight fixes and reviews, preparation of t he second X-43A and booster for flight at Mach 7 pending findings of the Mishap Investigation Board report in early CY 2002.

PROGRAM PLANS FOR FY 2003

During FY 2003, **Propulsion and Power** will investigate fluid-dynamic and structural "morphing" of gas turbine components. These technologies have the potential to enable an engine to adapt itself to any given flight condition, thus ensuring optimum efficiency and minimal emissions at every point in the flight mission. Engine subsystems, including foil and magnetic bearings, that have the potential to completely eliminate the need for oil and lubrication systems will be investigated. Other technologies, such as a high temperature-capable actuator, which is planned for fabrication and test in FY2003, will help to enable gas turbine engine self-diagnosis, self-reconfiguration, and self-repair. Also, in FY 2003 Propulsion and Power will demonstrate the utilization of a high temperature Polymer Matrix Composite in a harsh environment that consists of a rapid heat-up from cryogenic temperatures, short durations at extremely high temperatures, and rapid cool down over hundreds of cycles; while decreasing the overall design weight of the component by 25 - 30%. Further, in FY 2003, Propulsion and Power will continue investing in non-combustion-based propulsion systems.

The driving research activities for **Flight Research** in FY 2003 will be flight demonstration of Intelligent Flight Control Systems applications in the F-15 and C-17 platforms and continued expansion of the Helios aircraft's flight duration capabilities. The C-17 testbed aircraft will begin flight-testing with a Research Flight Control System (REFLCS) that will provide an unparalleled in-flight research capability. The Active Aeroelastic Wing (AAW) technology program will demonstrate closed loop control of flight utilizing wing twist in a modern aircraft. The F-15B testbed aircraft will complete experiments in Laminar Flow, Space-based Telemetry And Range Safety (STARS), and F-5 Shaped Boom Demonstration.

In FY2003 **Ultra Efficient Engine Technology** will begin to transition its most promising technology approaches from laboratory tests into experimental evaluations of more realistic configurations. Specifically sector tests of promising ultra low NOx combustor concepts will be completed and the most promising large engine and small engine concepts will be carried forward into full scale annular rig designs (working in partnership with industry). These TRL5 tests will be conducted in the remaining years of the program. The ceramic thermal barrier coating selected in FY2002 will be used along with the baseline ceramic matrix composite (CMC) to design a complex part (i.e. turbine vane) which will validate a material system with a 3000 °engine flow path capability (2700 °vane surface temperature capability). The most promising approach for active flow control will be demonstrated in a small-scale wind tunnel test of a Blended Wing Body (BWB) S-inlet. An interim technology benefits assessment will be conducted of all the technologies being developed in the UEET Program and their individual and collective impact on meeting the overall program goals. Construction will begin on the Dual-Spool Turbine Facility (DSTF) in FY2003, with the DSTF being ready for testing in FY2004.

In FY 2003 **Quiet Aircraft Technology** will develop physics-based models related to noise generation and propagation physics for airframe and engine noise sources as well as noise interaction between engine and airframe. The models will be used to design, optimize, and implement the noise reduction concepts developed in QAT, and used by our industry partners to implement the QAT-developed noise reduction concepts on their products. The validated models enable an understanding of the details of noise production and propagation which is essential for the discovery and development of advanced noise reduction concepts as well solutions to issues not even envisioned today.

In FY 2003, **Breakthrough Vehicle Technologies** will the annual OAT goals assessment and system studies of several revolutionary concepts. Breakthrough Vehicle Technologies will demonstrate the viability of a preliminary set of miniaturized NDE (Non-Destruct Evaluators) end-effector technologies for low cost inspections of critical components for use in inaccessible regions or hazardous environments. Breakthrough Vehicle Technologies will also demonstrate the ability for laboratory-scale production of carbon nanotube laminates with a high performance polymer matrix. Breakthrough Vehicle Technologies will develop validated figures of merit and design guidelines for the prevention of abrupt wing stall in future fighter designs. Test the Stingray vehicle (supporting the Morphing Project) to demonstrate open-loop distributed micro flow control enabling advanced vehicle maneuvering through virtual aerodynamic shaping. Breakthrough Vehicle Technologies will evaluate adaptive drag reduction technologies that may include shock wave manipulation, near wall turbulent structure manipulation, and the delay of laminar to turbulent transition.

In FY 2003 the **Twenty-First Century Aircraft Technologies** Project will focus on the development of the following technologies: Flutter risk assessment of a high speed slotted wing to provide experience with flutter mechanisms, flutter prediction capabilities and confidence to proceed with industry high-speed airplane concepts. Validate nonlinear structural analysis tools for determining the stiffness and strength response of a noncircular multi-cell structure subjected to combined loads. Develop transient disturbances recovery strategy for implementation in the SPIDER (Scaleable Processor Independent Design for Electro-Magnetic Resilience) architecture to ensure the aircraft's flight control system is robust. Quantify the benefits of a suite of conventional and unconventional vehicle/architecture configuration and technology solutions on future vehicle concepts. Demonstrate a dual channel (one propulsion and one secondary power channel) regulated, integrated, and Propulsion and Power system test bed – the first end-to-end demonstration of an electric P&P system including fuel cell power generation and realistic loads, actuators and motors) configured for aircraft requirements.

In FY 2003 **Advanced Vehicle Concepts** will focus on the following specific activities: Conduct Parameter identification flights of the Active Aeroelastic Wing to measure wing twist (flexible wing) effectiveness in flight on an F-18 to determine available roll power and demonstrate closed loop control of wing twist (flexible wing) on the F-18. Generation I flight testing of the F-15 flight test vehicle and the Research Flight Computing System (REFLCS) will begin during this year. Activities in the **Hyper-X (X-43A) program** in FY 2003 will include preparations for and the final flight that will be at Mach 10. These flights will establish the capability of U.S. advanced hypersonic design tools and provide the foundation for the transition to the NASA/Air Force X-43C project, a part of the Advanced Space Transportation Program, which will demonstrate acceleration from Mach 5 to 7 under scramjet power.

(Budget Authority in Millions of Dollars)

ERAST – LIFE CYCLE COST (LCC)	**PRIOR**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**TOTAL**
BOLD ERAST	119.1	10.5						129.6
ERAST II	12.0	11.5	20.0	0.0	0.0	0.0	0.0	43.5
TOTAL (EXCLUDES CIVIL SERVICE COST ($M)	121.1	22.0	20.0	0.0	0.0	0.0	0.0	173.1
(ESTIMATED CIVIL SERVICE FTEs *								
CIVIL SERVICE COMPENSATION ESTIMATE ($M) *								

* ERAST is a project within the Flight Research program: NASA tracks Civil Service FTEs and compensation only down to the program level, thus no separate data is available for ERAST.

(Budget Authority in Millions of Dollars)

Hyper-X – LIFE CYCLE COST (LCC)	PRIOR	2002	2003	2004	2005	2006	2007	TOTAL
HYPER-X PROJECT	175.0	25.0	17.0	0.0	0.0	0.0	0.0	217.0
TOTAL (EXCLUDES CIVIL SERVICE COST ($M)	175.0	25.0	17.0	0.0	0.0	0.0	0.0	217.0
(ESTIMATED CIVIL SERVICE FTEs *								
CIVIL SERVICE COMPENSATION ESTIMATE ($M) *								

* HYPER-X is a project within the Vehicle Systems Technology program: NASA tracks Civil Service FTEs and compensation only down to the program level, thus no separate data is available for HYPER-X

BASIS OF FY 2003 FUNDING REQUIREMENT

AIRSPACE SYSTEMS PROGRAM

Web Address: http://www.asc.nasa.gov

	FY 2001	FY 2002	FY 2003
		(Millions of Dollars)	
Airspace Systems Program	**125.9**	**133.9**	**125.1**
Terminal Area Productivity (TAP) project	5.4	--	--
Short Haul Civil Tiltrotor (SHCT) project	3.4	--	--
Advanced Air Transportation Technologies (AATT) project	59.6	71.4	71.6
Small Air Transportation System (SATS) project	9.0	15.5	20.0
Virtual Airspace Modeling and Simulation (VAMS) project	--	23.0	23.0
Airspace Operations Systems (AOS) project	16.9	11.5	10.5
Rotorcraft	31.6	12.5	--

DESCRIPTION/JUSTIFICATION

The Airspace Systems (AS) program will enable the development of revolutionary improvements to, and modernization of, the air traffic management (ATM) system, as well as the introduction of new vehicle systems and classes whose operation can take advantage of an improved, modern ATM system. The customers for this technology are the Federal Aviation Administration (FAA), commercial and private aviation operators, and aircraft developers and system suppliers.

The primary objective of the AS Program is to enable new aircraft capabilities and air traffic technology to increase the capacity and mobility of the air transportation system. The secondary objectives are to assure safety, security and environmental protection while maximizing operational efficiency, flexibility, predictability and access into the airspace system. The public is the beneficiary of this program - both from an economic viewpoint as well as from an improved life style. The benefits to the user will be reduced travel delays and increased community access. The major challenges are: to accommodate projected growth in air traffic while preserving and enhancing safety and security; provide all airspace system users more flexibility and efficiency in the use of airports, airspace and aircraft; enable new modes of operation that support the FAA commitment to “Free Flight” and the Operational Evolution Plan (OEP), and maintain pace with a continually evolving technical environment.

The capacity of the airspace system can be increased by: (1) increasing the number of runways, (2) increasing the throughput of airport runway and taxiways in weather, (3) improving gate-to-gate air traffic flow/management/control, (4) off-loading main runways of small aircraft for use by large transports, and (5) increasing use of alternate small airports.

Airspace Systems consists of four projects: Airspace Operations Systems (AOS), Advanced Air Transportation Technologies (AATT), Virtual Airspace Modeling and Simulation (VAMS), and Small Aircraft Transportation System (SATS). The major focus of the AOS, AATT, and VAMS projects is to improve the capacity of transport aircraft operation at and between major airports in the National Airspace System. The focus of the SATS project is a demonstration of the use of general aviation to improve mobility. The **TAP** project, which was successfully completed in FY 2000, developed technologies to increase the throughput of single and parallel runways and taxiways in weather conditions that cause low visibility. The **SHCT** project, which was successfully completed in FY2001, developed technologies to enable a quiet and safe capability to off-loading small aircraft from the runways at large airports so that large transport aircraft can use them.

The **AOS** project develops fundamental understandings, models and tools needed to conceive and model the NAS and its human operators as well as to provide the foundations for development and operation of safe systems.

The **AATT** Project is developing decision support tools to help air traffic controllers and pilots improve the air traffic management and control process from gate-to gate. The goal of the AATT project is to increase the effectiveness (capacity, efficiency, flexibility, predictability and safety) of the national and global air transportation system. The specific objectives are to:

- Enable user flexibility to the maximum degree possible so that users may minimize direct operating costs by making trade-offs between time and routing.
- Improve the effectiveness of high-density operations in regions on the ground and in the air where maximum user flexibility may not be possible.
- Enable operation in a smooth and efficient manner between high user flexibility and lower user flexibility regions of the NAS.
- Provide system improvements that are easily deployable anywhere in the world. The VAMS project is exploring the next generation of ATM concepts and developing the analytical and simulation capability needed to analyze and validate these concepts.

The **VAMS** project is exploring the next generation of ATM concepts and developing the analytical and simulation capability needed to analyze and validate these concepts. The goal of the VAMS project is to explore new concepts and develop modeling/simulation capabilities that will be precursors to a 200% increase (tripling) in the NAS capacity by 2022 based on 1997 levels. The overall objectives/approach of the VAMS project are to:

- Develop and assess advanced system-level air transportation concepts.
- Conduct system-level assessments of this concept set.
- Develop the capability to model and simulate behavior of the air transportation system operations to never-before-achieved levels of fidelity.
- Develop a set of analytical and computational models and methods to conduct detailed assessments of candidate operational concepts.

The major focus of the **SATS** project is to improve public mobility and community access to aviation by enabling use of under-utilized airports across the country. The goal of the five-year SATS project is to develop key airborne technologies and provide a proof of concept through an integrated technology evaluation and validation of precision guidance of small aircraft to virtually any touchdown zone at small airports. The SATS project has four objectives centered on enabling operational capabilities that are not possible in the current National Air Space (NAS) environment. These objectives are:

- Higher Volume Operation at Non-Towered/Non-Radar Airports.
- Lower Landing Minimums at Minimally Equipped Landing Facilities.
- Increase Single-Pilot Crew Safety and Mission Reliability.
- En Route Procedures and Systems for Integrated Fleet Operations.

The key airborne technologies to support the creation and evaluation of SATS-oriented operating capabilities would enable near all-weather operations by new generations of aircraft at virtually any landing facility in the nation.

Funding is included under this program for selected Congressional special interest initiatives identified in the FY 2002 Appropriations Act.

STRATEGIC OBJECTIVE:	**PROGRAM APPROACH:**
Revolutionize Aviation - Increase Capacity	Develop and transfer to the FAA and airlines decision support tools to help air traffic controllers and pilots improve the air traffic management and control process from gate-to gate. Develop the analytical and simulation capability needed to analyze and validate next generation air traffic management concepts.
- Increase Mobility	Develop key airborne technologies for precise guided accessibility for small aircraft in near all-weather conditions to virtually any small airport in non-radar, non-towered airspace. Conduct proof of concept demonstrations of these technologies.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Revolutionize Aviation
Strategic Plan Objectives Supported: Expand Aviation Capacity, Improve Mobility
Performance Plan Metrics Supported: APGs 3R4, 3R5

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-03 Change	Comment

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-03 Change	Comment
Rotorcraft Analytic model predictions of rotorcraft crashworthiness		2/01	1/01	Complete	Finite element modeling has been used to characterize the airframe, aircraft skins, impact media (water and soil), and contact surface. A simulation of the crash tests in both soft soil and water have been computed, along with resulting accelerations and damage to the rotorcraft structure. Crash tests in both water and soft soil have been performed with full-scale hardware. January 2001 test results have validated the models
Health and usage monitoring systems (HUMS) certification protocol		2/01	2/01	Complete	The RITA (Rotorcraft Industry Technology Association)-Health Usage & Maintenance System (HUMS) open architecture protocol includes 5 separate specifications, developed in collaboration with the FAA and DoD. Each of these specifications have been submitted to SAE for review and are expected to transition to SAE standards. The specifications define the aircraft data system and data bus, transducers, signal conditioning and data protocols, and the ground data system.
Ultra-safe gear design guide		3/01	3/01	Complete	The guide predicts crack propagation paths and has been validated using the NASA Gear Fatigue Test Rig.
Flight-validate advanced control laws/modes		9/01	9/01	Complete	A control system, representative of a small civil helicopter, was designed and implemented on RASCAL (Rotorcraft Aircrew Systems Concepts Airborne Laboratory) using the RFCS (Research Flight Control System), and verified by flight-testing. The flight tests verified that CONDUIT (Control Designer's Unified Interface) could design to level 1 HQ for flight tasks typical of the most demanding civil operations.

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-03 Change	Comment
Rotorcraft technology documented		9/01	9/01	Complete	Over 160 technical experts and technology managers, members of the NRTC/RITA (National Rotorcraft Technology Center / Rotorcraft Industry Technology Association)* organization, met to share results of all the projects completed this year. In the three-day meeting technology transfer reports were presented for 96 of 98 projects for the year 2000 NRTC/RITA* technical program, which exceeded the goal of presenting at least 85% of the projects.
Short-Haul Civil Tiltrotor					
Comprehensive mission simulation database of integrated cockpit and operating procedures for complex, low-noise flight paths		9/01	9/01	Complete	See discussion in the accomplishments section below.
Large scale database for validation of rotor noise reduction and validated design for noise capability (TRAC)		9/01	9/01	Complete	See discussion in the accomplishments section below.
Airspace Operations Systems					
Characterize the demands of concurrent task management and patterns of errors		5/01	5/01	Complete	Published the second and third of a series of reports characterizing the demands of managing concurrent tasks and laying the groundwork for developing methods pilots can use to reduce their vulnerability to forgetting to perform critical actions because of preoccupation with other duties
Develop initial bio-mathematical model enabling prediction of flight crew performance based on sleep and circadian models		6/01	6/01	Complete	Findings demonstrate that brief, hourly in-flight activity breaks reduce physiological and subjective sleepiness for at least 15 minutes during the circadian trough, and may have continued effects for up to 25 minutes.
Model for planning flight crew scheduling	6/02	6/02	6/02		
Provide strategies for improving training and procedures to reduce misunderstandings between pilots and air traffic controllers	6/03		6/03		

Advanced Air Transportation Technologies					
Develop and demonstrate transition airspace decision support tools. These tools will enable information exchange between ATC/airline operations centers and ATC/cockpits for collaborative decision-making. These tools will also enable prediction of aircraft conflicts both by ATC and flight crews.		9/01	9/01	Complete	See discussion in the accomplishments section below.
Develop and evaluate a traffic flow management decision support tool for system-wide prediction of sector loading	12/01		12/01		
Develop and demonstrate an interoperable suite of decision support tools for arrival, surface and departure operations	3/02	3/02	3/02		
Develop, demonstrate initial functionality, and evaluate human factors for a decision support tool for complex airspace	12/02		12/02		New milestone in response to Independent Annual Review request for additional milestone detail.
Develop, demonstrate initial functionality, and evaluate human factors for one active terminal-area decision-support tool	9/03		9/02	+12 months	Slipped one year and reduced to one tool due to FY2002 congressional budget reduction and unfunded earmarks.
Virtual Airspace Modeling & Simulation					
Complete VAST real-time environments definitions and preliminary design	9/02	9/02	9/02		
Identify candidate future Air Transportation System capacity-increasing operational concepts	9/02	9/02	9/02		

Complete Build 1 of state-of-the-art airspace models toolbox with the ability to assess economic impact of new technology and NAS operational performance, and the ability to model the dynamic effects of interactive agents	3/03		3/03		
Small Aircraft Transportation System					
Systems engineering documents baselined	3/02	12/01	12/01	+3 months	Baselining of documents will occur in March-2003 when SATS Consortium is established.
Initial SATSLab flight experiments conducted	9/03		9/03		
Technology downselect for flight experiments	12/02		12/02		

Lead Center: Ames Research Center	**Other Centers:** Glenn Research Center, Langley Research Center	**Interdependencies:** FAA
Project	**Lead Center**	**Industry Contractors**
Airspace Operations Systems	Ames Research Center	Numerous grants
Advanced Air Transportation Technologies	Ames Research Center	Raytheon, CSC, and their partners; NRA with SAIC and SRC
Virtual Airspace Modeling & Simulation	Ames Research Center	Raytheon, CSC, and their partners; new competitive NRA and contracts
Small Aircraft Transportation System	Langley Research Center	Broad public-private partnership encompassing industry, academia, and government entities utilizing a cost-sharing Joint Sponsored Research Agreement
Program Product	**Builder (Location)**	**Product Benefit**
Terminal Decision Support Tools	Multi-contractor	Terminal throughput increased by 10 percent using near-term decision support tools for scheduling, runway assignment and landing order. Terminal throughput increased by 15 percent using mid-term and far-term decision support tools and operating concepts for multi-Center traffic coordination, air-ground data exchange, interoperable surface/departure operations, and air/ground collaboration for arrival spacing.

En route Decision Support Tools	Multi-contractor	En route throughput increased by 10 percent using near-term, mid-term, and far-term decision support tools and concepts for metering or spacing of traffic, efficient conflict-free routing, and air/ground collaborative TFM and control.
Decision Support Tools for Flexibility and Collaboration	Multi-contractor	Three decision support tools/ concepts developed that provide new capabilities for flexibility or collaboration for airspace users and service providers.
Airspace Modeling Toolbox	Multi-contractor	Complete VAST airspace models toolbox with the ability to assess economic impact of new technology and NAS operational performance, and to model the effects of interactive agents and weather, suitable for use in evaluating advanced OpsCons.
Real-Time Virtual Airspace Simulation System	Multi-contractor	Complete development of real-time VAST capabilities for use in evaluating advanced OpsCons. Provide capability for integrated air traffic control and aircraft simulation.
Innovative Concepts for National Airspace System	Multi-contractor	Explore innovative NAS concepts that will enable throughput increases of an additional 50% based on 1997 levels.
Non-Procedural Separation in Non-Radar Terminal Airspace	Multi-contractor	Demonstrate the ability to eliminate “procedural separation” requirements in IMC in non-radar terminal airspace and allow 2 or more simultaneous operations at a time (> 6 landings per hr)
IFR-type Approach/Landing at VFR-only Airports	Multi-contractor	Demonstrate the ability to provide precision- like approach and landing guidance that requires no new land acquisition, no approach lighting, and minimal new ground-based equipment with minimum ceiling and visibility requirements of 200 ft and 1/2 miles respectively at a currently VFR-only airport
Single Pilot System	Multi-contractor	Single-pilot precision, safety, and mission reliability equal to that of a single ATP crewmember with current instrumentation
Airborne Enabling Technologies	SATS Alliance	Elimination of “procedural separation” requirements in IMC in non-radar terminal airspace and allow 2 or more simultaneous operations at a time.

		Ability to provide precision like approach and landing guidance that requires no new land acquisition, no approach lighting, and minimal new ground-based equipment with minimum ceiling and visibility requirements of 200 ft and 1/2 mile, respectively, at a currently VFR-only airport. Single-pilot precision, safety, and mission reliability equal to that of a single ATP crewmember with current instrumentation.
Transportation Systems Analysis and Assessment	SATS Alliance	Analysis of the impact of operations enabled by SATS technologies on higher en route air traffic flows and terminal airspace operations in the current NAS.

PROGRAM STATUS/NOTIFICATIONS/PLANS THROUGH 2002

In FY 2001 the **Short Haul Civil Tiltrotor** project was successfully completed on schedule. Completed final SHCT full mission simulation experiment incorporating all knowledge gained from SHCT project. The experiment included cockpit and low-noise flight operations research on safe manual control in adverse weather with simulated emergency conditions. Takeoffs, landings, go-arounds and engine failure recoveries were investigated in a congested airspace scenario based upon a vertiport at San Francisco International airport. Developed initial strategy for simultaneous non-interfering operations at a hub airport. Steep 9-degree final approach found to maximize separation altitude from transport aircraft on runways while lowering noise footprint. Cockpit technologies and design/certification procedures transferred to Bell Textron BA609 commercial tiltrotor design. The SHCT project demonstrated flight operational noise footprint reductions of up to 10dBA, exceeding the target performance of 6 dBA. Completed the large-scale database and the prediction code for design-for-noise capability. The program finalized the database for low-noise proprotor designs, analysis capability for design and evaluation of low-noise tiltrotors, and validation of design for noise capability. Finalized and delivered Tiltrotor Aircraft Noise Prediction Code (TRAC) to Bell, Boeing and Sikorsky. The SHCT project demonstrated reductions of up to 12.5 dBA in proprotor noise, exceeding the target performance of 6-dBA reduction in source noise.

In FY 2001, there was an orderly close-out of the **Rotorcraft Base R&T Program**. An Ultra-Safe Gear Design Guide was published. A composite structures certification methodology was delivered for inclusion in Mil-Std Handbook 17. A new physics-based design tool was provided for prediction of composite structure stringer/ skin separation mode of failure. Flight tests were completed that demonstrated and validated control laws for low pilot workload under typical civil operations. Crashworthiness tests on rotorcraft demonstrated mitigation of damage to airframe structures due to crash/ harsh landings. New HUMS (Health and Usage Monitoring Systems) protocols were developed for improved safety and maintenance. There was a demonstration conducted for the new “express- tool” technology that reduced design to fabrication time by 50%. Although the Rotorcraft Research Program was concluded in FY 2001, NASA will fund the NASA/Army Rotorcraft University Centers of Excellence in FY 2002 as directed in the VA, HUD, and Independent Agencies Appropriations Act. NASA does not anticipate funding this program in FY 2003. In addition, NASA will use the remaining directed funding to continue the Runway Independent Aircraft (RIA) activity and identify key enabling technologies for these vehicles. In FY 2002, this includes examination key issues associated with operating tilt-rotor like air vehicles in the approaches and terminal areas. We plan to focus on aerodynamics, vehicle management and information systems, and operational issues connected with large rotor, large aircraft and with controllable, quiet, and safe operations in the low speed regime near terminals. Future NASA work in rotorcraft will be assessed and prioritized against other approaches to increasing nation's air systems capacity under the other Airspace Systems projects described below.

In the **Airspace Operations Systems** project for FY 2001, training research was concentrated on characterizing how the demands of managing multiple concurrent tasks contribute to crew errors in aviation incidents and accidents. This work will lead to later development of methods to train pilots to manage concurrent task demands safely and operating procedures to reduce excessive demands. Fundamental modeling of human performance and the interaction of human operators with automated systems continued. Cognitive tools were developed and documented for task evaluation and management as they support human performance. These tools were developed using a combination of empirical investigation, modeling, and direct measurement of brain activity. Technologies for the ground-based remote sensing of aviation icing conditions were reviewed and evaluated leading to the selection of candidate systems to develop for future field tests. These systems will lead to improved pilot interpretation and management of icing hazards, better management of air traffic in adverse weather conditions, and reduced in-flight icing incidents and accidents during approach and landing.

During FY 2002, the **Airspace Operations Systems** project will enter a new phase in countermeasures for flight crew fatigue with the development of tools to assist aircraft operators in scheduling flight crews. An initial bio-mathematical model will be developed to predict crew behavioral performance based on sleep and circadian variables. New perceptual measurement tools for evaluating display effectiveness as they support human performance will be validated. This research is conducted using a combination of psychophysical studies, eye tracking, image processing, visual system modeling, auditory system modeling, virtual environment technologies, and interactions of perceptual factors with displays and controls. A methodology for the design and verification of task-driven human-automation systems will be developed. This methodology will enable verification that a given human-automation interface is "clean" of design errors and enable the building of interfaces that are sound and efficient.

In FY 2001 the **Advanced Air Transportation Technologies** project completed all work associated with the Collaborative Arrival Planner (CAP) tool. CAP provides the airlines with Air Traffic Control (ATC) situational awareness previously available only to the FAA to enable better decisions regarding flight diversions, pushback times, and other factors leading to improved operational efficiency. CAP is currently operational in the American Airlines operations center and the Delta ramp tower at Dallas Ft. Worth Airport. It was also distributed to the airlines through the collaborative decision-making network operated by the Volpe National Transportation Systems Center. A flight evaluation of Enroute Data Exchange (EDX) was completed. Under an MOU with United Airlines, the FAA and NASA, 48 Boeing 777 aircraft were outfitted with the EDX software to provide automatic real-time extraction and transfer of aircraft state and intent information to the NASA Center TRACON Automation System (CTAS). Data was collected from over 1000 flights during a 6-month period. Utilization of these data by the CTAS trajectory prediction algorithm resulted in significant improvements in the predicted trajectories of the aircraft. The Direct-to (D2) tool completed its first extensive field test at the Dallas-Ft. Worth (DFW) Center. Direct-to automatically identifies to the enroute air traffic controller any aircraft that can save flight time by flying directly to a waypoint further along its flight path. The D2 also probes for potential conflicts and allows the controller to trial flight plan to resolve conflicts quickly. Significant flight time savings were achieved including consistent savings of 50 to 60 seconds for one DFW departure route. During FY 2002, the Advanced Air Transportation Technologies project will demonstrate through simulation an interoperable suite of decision support tools for arrival, surface and departure operations. Development work in FY 2002 will lead to the transfer of surface management system technology to the FAA Free Flight Phase 2 Program in FY 2004. This capability will reduce arrival and departure delays and inefficiencies that occur on the airport surface due to surface issues and downstream restrictions.

During FY 2002, the **Virtual Airspace Modeling** project will develop requirements and preliminary design for a high fidelity modeling and simulation environment for the real-time investigation and validation of revolutionary operational and technological concepts for the next generation of airspace systems. The project will also identify and define the first new operational concept for future investigation using the new virtual airspace simulation technology capability.

In FY 2001 the **Small Air Transportation System** project established four SATSLab teams Virginia, Florida/Southeast, North Carolina/Upper Great Plains, and Maryland. They will perform work through May 2002 in four areas: system engineering, systems analysis, flight demonstration planning, and technology integration. Each team includes representatives from the state aviation/transportation departments, private industry, general aviation user groups, and academia and other non-profit organizations. This work is the precursor to the formation of a SATS Alliance. The SATS Alliance structure will be defined and implemented in March 2002, which will include a signed Joint Sponsored Research Agreement, a draft business operating handbook and an implementation plan for co-location of consortium and NASA personnel. Additionally, the SATS project will complete the project's baseline system engineering and technology documents, which form the basis for all technology investment and down-select decisions. The systems architecture necessary to enable the four operating capabilities will be defined. Additional environmental and economic impact studies to support the program assessment process will be initiated in FY2002 as will a total system cost study. A key activity for FY 2002 is the development of a simulation environment in which the flight path management and flight deck technologies will be assessed. Technology ground based experiments, which begin in FY2002, will establish the technology sets to be evaluated during the FY 2003 flight experiments. In support of these experiments, modifications to the flight research test beds will begin in FY 2002. Sites used for technology development flight experiments, integrated technology validation flight tests and integrated technology flight demonstration will be selected. The process by which sites will be selected for each phase will be mutually agreed upon between NASA and the SATS Consortium. NASA expects that the number of integrated technology flight demonstration sites will be a limited subset of those sites used during the technology development and validation phases of the SATS project.

PROGRAM PLANS FOR FY 2003

In FY 2003 the **Airspace Operations Systems** project will develop strategies to improve training and procedures to reduce misunderstandings between pilots and air traffic controllers. The results of this study will be provided to the operational community.

In FY 2003 the **Advanced Air Transportation Technologies** project will develop, demonstrate initial functionality, and evaluate human factors for a decision support tool for complex airspace. The project will also develop, demonstrate initial functionality, and evaluate human factors for an active terminal-area decision-support tool. These demonstrations and evaluations will be conducted in either a high fidelity simulation or a shadow field-test and enable user flexibility to the maximum degree possible so that users may minimize direct operating costs by making trade-offs between time and routing.

In FY 2003 the **Virtual Airspace Modeling and Simulation** project will complete Build 1 of a toolbox of state-of-the-art models of the airspace system. This toolbox will include the capability to model the dynamic effects of interactive agents in the National Airspace System. These models will provide the capability to assess the economic impact of new technologies on the operational performance of the National Airspace System as well as the commercial air transport industry.

In FY 2003 the **Small Air Transportation System** project will select candidate technologies for experimental flight evaluation based on their impact on mobility either through reduced system cost, improved doorstep-to-destination time, increased trip reliability, and/or improved safety. The project will complete initial experimental flight evaluations of key enabling technologies. These flight experiments, in conjunction with the technology analyses and assessments, will evaluate individually, at the sub-system level, the impact of selected technologies on lowering required landing minimums and increasing the volume of operations at non-towered landing facilities in non-radar airspace during instrument meteorological conditions.

BASIS OF FY 2003 FUNDING REQUIREMENT

2ND GENERATION REUSABLE LAUNCH VEHICLE (2ND GEN) PROGRAM

Web Address: http://SLInews.com

	FY 2001	FY 2002	FY 2003
		(Millions of Dollars)	
2nd Generation Reusable Launch Vehicle Program	**289.4**	**467.0**	**759.2**
Systems Engineering and Requirements Definition	49.9	83.8	64.1
RLV Competition / Risk Reduction	94.8	280.1	501.5
NASA Unique Systems	41.7	28.4	108.8
Alternate Access	39.9	48.7	62.7
Future X / X-37	45.2	26.0	22.1
X-34	17.9	--	--

DESCRIPTION/ JUSTIFICATION

The Space Launch Initiative (SLI), also known as the 2nd Generation Reusable Launch Vehicle (2nd Gen RLV) Program, is the central element of NASA's Integrated Space Transportation Plan (ISTP), which is NASA's long-range strategy for safer, more reliable, and less expensive access to space. ISTP consists of three major elements Space Shuttle safety investments and competitive sourcing, the 2nd Gen RLV Program, and far-term technology investments (Space Transfer and Launch Technology) – that are closely coordinated to address NASA's near-, mid- and far-term launch needs.

The 2nd Gen RLV Program is NASA's comprehensive plan to improve access to space in the mid-term. 2nd Gen RLV investments during the first half of this decade aim to enable a mid-decade competition for full-scale development of a launch architecture that could dramatically increase safety and reduce costs. By reducing risk through requirements trades, technology maturation, and cost-effective testing in relevant environments, 2nd Gen RLV will form the foundation for full-scale development of a new launch architecture in the latter half of this decade leading to flight operations early next decade.

The 2nd Gen RLV Program consists of three major elements: Systems Engineering and Requirements Definition, RLV Risk Reduction and Competition, and NASA Unique Systems risk reduction. In addition, a fourth element, Alternate Access to the International Space Station (ISS), seeks to provide NASA with commercial means of servicing the Space Station this decade. Building on 20 years of success with America's 1st Generation RLV— the Space Shuttle — the 2nd Gen RLV is the plan of action to design and develop NASA's next-generation RLV. The 2nd Gen RLV Program, is based on the philosophy that meeting NASA's human space flight needs on highly reliable, commercial competitive, privately- operated reusable launch vehicles will significantly reduce the cost of space access, allowing the Agency to focus resources on its core missions of scientific discovery and exploration.

In partnership with the Department of Defense (DoD), the U.S. aerospace industry, and academia, NASA will perform systems engineering, technology development and architecture definition trade studies to define at least two launch architectures that will best meet mission requirements. The NASA Research Announcement (NRA) 8–30 procurement for 2nd Generation RLV design and development activities took into account extensive NASA studies and contractor-provided input from NRA 8–27, which focused on detailed requirements evaluation, updated market projections, and risk-reduction priorities and plans. This systematic approach targets the research and development of high-priority technologies — such as lightweight structures, long-life rocket engines, advanced crew systems, life support, rendezvous and docking systems, flight control and avionics, and thermal protection systems — to be integrated into at least two vehicle architectures that will compete to go into full-scale development around mid-decade, with operations early next decade.

STRATEGIC OBJECTIVE:	PROGRAM APPROACH:
Advance Space Transportation - Mission Safety - Mission Affordability	Perform systems engineering, technology development and architecture definition trade studies to define at least two 2nd Generation RLV architecture designs that will best meet the requirements to make access to space safer, more reliable, and less expensive for present and future customers. The systematic approach targets the research and development of high-priority advanced technologies to be integrated into at least two vehicle architectures to provide the foundation for future potential full-scale development decisions.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Advance Space Transportation
Strategic Plan Objectives Supported: Mission Safety, Mission Affordability
Performance Plan Metrics Supported: APGs 3R6, 3R8

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-03 Change	Comment
NASA Research Announcement					
NRA 8-30 Cycle II Contract(s)	11/02	11/02	11/02		
Request for Proposal	11/02	11/02	11/02		
Non-advocate Review	10/02	10/02	10/02		
Systems Requirements Review	11/02	11/02	11/02		
Interim Architecture Technology Review	3/02	3/02	3/02		
NASA Research Announcement Contract Award	5/01	4/01	1/01	+1 month	Evaluation and selection process required additional time to complete and make the necessary notifications prior to public announcement

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-03 Change	Comment
Initial Architecture Review (IAR)	3/02	2/02	2/02	+1 month	IAR has been combined with the (Risk Reduction Review (RRR) to form an integrated Interim Architecture and Technology Review (IATR). The IATR is a 12 week process that will conclude with final reporting in March 2002
Propulsive Small Expendable Deployer Systems (ProSEDS) Complete	9/02	8/01	12/00	+13 months	Experiment is a secondary payload on Delta II and has been re-manifested for a June 2002 launch.
X-37 roll out		9/01	9/01	Deleted	The planned rollout of the X37 was delayed due to the program restructure and negotiations with the contractor. No planned date has been announced at this time
X37 Atmospheric Drop test		1/02	1/02	Deleted	The atmospheric drop test has been delayed until the mid FY05 timeframe. Program is currently working issues with the test article and the B52 test platform. The atmospheric drop test has been delayed until the mid FY05 timeframe. Program is currently working issues with the test article and the B52 test platform.
X37 First Orbital Flight		6/03	9/02	Deleted	The orbital flight of the X37 vehicle has not been scheduled. The actual date will depend upon the needs and requirements of the Space Launch Initiative and the Flight Demonstrations Project
COBRA Engine Critical Design Review	10/02		10/02		This milestone is dependant upon results of the IATR
RS-83 Engine Preliminary Design Review	2/03		2/03		This milestone is dependant upon results of the IATR
Request for Proposal (RFP) Release	2/03		2/03		Contract awards to selected architectures leading toward a preliminary design level of 2nd Generation RLV

Lead Center: Marshall Space Flight Center	**Other Centers:** Glenn Research Center, Langley Research Center, Ames Research Center	**Interdependencies:**

Project	**Lead Center**	Industry Contractors
System Studies and Architecture Definition	Marshall Space Flight Center	Boeing, Lockheed Martin, Orbital Sciences, Futron, Northrop Grumman
Airframe	Langley Research Center	Northrop Grumman, Boeing Seal Beach, Oceaneering, Lockheed Martin, North Carolina State University, Materials Research and Design, Southern Research Institute
Vehicle Subsystems	Glenn Research Center	Boeing Seal Beach, Lockheed Martin
Operations	Kennedy Space Center	Boeing, Sierra Lobo, PHPK Technologies, Lockheed Martin
IVHM	Ames Research Center	Northrup Grumman, Honeywell Space Systems, Lockheed
Upper Stages	Marshall Space Flight Center	General Kinetics, Rocketdyne, Moog, Pratt & Whitney
Flight Mechanics	Marshall Space Flight Center	Universal Space Lines, Ohio University
Propulsion	Marshall Space Flight Center	Rocketdyne, Pratt & Whitney, TRW, Boeing Seal Beach, Aerojet, Andrews Space & Technology
NASA Unique Systems	Johnson Space Center	Lockheed, Honeywell Engines & Systems
Flight Demonstrations	Marshall Space Flight Center	Orbital Sciences DART, Kistler K-1

Program Product	**Builder (Location)**	**Product Benefit**
Architecture Definitions: A minimum of 2 RLV architecture definitions and system designs.	Multiple	Defining the architectures allows for focusing of technology maturation leading to the optimum low cost, high reliability RLV.
Control Surface Structure and Joining Technology, Cryotank Producibility analysis, Durable Thermal Protection System (TPS) airframe technology development	Multiple	Advanced ceramic and metallic composite materials will reduce operations costs and increase reliability of future launch vehicles.
Power Technology, Actuators Technology	Multiple	Maturation of these technologies will reduce vehicle weight thus reducing development costs and increase payload capability.

Concept definition of Advanced Checkout, Control, & Maintenance Systems, Plans for Densified Propellant operations	Multiple	Reduction in turn-around time to flight allows for increased flight rate, thus decreasing the overall cost per launch.
IVHM Architecture definition, Systems Analysis and Optimization	Multiple	Real-time health monitoring of vehicle systems and subsystems allows for the forecasting and detection of system failures. This capability enables appropriate actions to be taken in a timely manner in flight thus increasing vehicle safety. Post-flight vehicle status reports provided by IVHM also reduce turn-around time and operations costs.
Upper stage propulsion system technologies	General Kinetics, LLC. Lake Forrest, CA	Will determine the operating and performance limitations of catalyst beds and characterize their sensitivity to propellant stabilizers and contaminates in upper stage propulsion systems, which will result in increased systems reliability.
Integrated Guidance & Control System	Ohio University	Develop innovative entry and autonomous abort control reconfiguration and an auto commander that integrates the guidance attitude controller. This robust software gives the vehicle more abort options decreasing the loss of vehicle probability toward 1 in 10,000.
Main engine and reaction control system development (RCS) and testing	Multiple	Maturation of these technologies has the greatest impact on reducing costs and increasing reliability associated with RLV development and operations.
NASA Unique Systems for crew escape and other human elements	Honeywell International Corporation Glendale, CA	Increases vehicle usability enabling higher launch rate thus decreasing overall launch costs.
Integrated technology validation	Kistler Aerospace Corporation, Kirkland, Washington, Orbital Sciences Corporation, Dulles, VA	Flight demonstration verifies technology readiness of critical technologies. Verification of technology to allow for low cost operations through autonomous flight operations near other orbiting vehicles such as Space Station.

PROGRAM STATUS/NOTIFICATIONS/PLANS THROUGH 2002

The **Space Launch Initiative (SLI)** is based upon a system engineering approach. The initial phase of the program is to solicit, integrate and refine mission needs and requirements for NASA's next generation of reusable launch vehicles. All contracts awarded under NRA 8-30 Cycle I were for a base period of 10 months to be followed by options for 1 or 2 additional years. The base period will conclude in March 2002. At that time the program will also conclude an Interim Architecture and Technology Review (IATR). The IATR is a four-month effort that culminates the Phase I Base Period and will provide the basis for architecture and technology down-selects. This is the next major milestone in the Space Launch Initiative. The outcome of the IATR will directly influence all follow-on activities. It will provide the basis to exercise Cycle I NRA 8-30 options or to terminate projects. Cycle II of the NASA Research Announcement (NRA 8-30) solicitation will be released in January 2002. Anticipated contract awards are scheduled for September 2002. This solicitation is the second under the 2nd Generation RLV program and will provide the first opportunity to address the technical gaps that were identified in the first round of solicitations. An Industry Briefing on Cycle II is scheduled for January 2002. The final amount and scope of contracts awarded under the Cycle II solicitation will depend upon the IATR results.

Program Office created and staffed at MSFC with 9 Project Offices at 6 NASA centers created and staffed. NRA 8-30 Cycle I solicitation is complete with multiple awarded contracts for the initial 2nd Generation RLV program solicitation (NASA Research Announcement NRA 8-30). Contracts were awarded in 10 technical task areas totaling approximately $800 million (includes base + options) to 23 companies. Specific areas include:

System Studies and Architecture Definition: Focused on research and technology development activities pertaining to system architectures and their appropriate risk reduction tasks. Integrated contracts were awarded to 4 industry partners and an additional contract was awarded under this task to conduct comprehensive market research and analysis. Results of the base period of these contracts will be presented during the Interim Architecture and Technology Review in March 2002.

Airframe: This task area focuses on the development and demonstration of the enabling technologies for robust, low cost, low maintenance structures, tanks, thermal protection systems and integrated thermal structures. Contracts were awarded to seven industry and academia partners.

Vehicle Subsystem: This task focuses on the definition, development and demonstration of a fault tolerant Vehicle Subsystems Architecture, and for the development and testing of power systems technologies, and high power flight control actuators. Two contracts were awarded to industry partners.

Operations: The task focuses on the development and integration of technologies for autonomous checkout and control of operational systems. The initial awards under this task are in the areas of advanced checkout and maintenance systems, and densified propellants.

Integrated Vehicle Health Management: The task focuses on the demonstration of the potential impact of an IVHM system to the program's safety and cost goals and the incorporation of enabling IVHM technologies into launch vehicle systems. Three contracts were awarded under in this area.

Upper Stage Propulsion: The contracts awarded under this task area are focused on non-cryogenic, low-toxicity propellant propulsion systems and the development of prototype component and systems for flight qualification. A total of four contracts were awarded during the initial selections.

Flight Mechanics: This effort is focused on the advancement of the current state-of-the-art flight software technologies that will enable robust guidance, navigation, and control systems for the next generation RLV. Two contracts were awarded during the initial selection process.

Propulsion: Contracts were awarded to six industry teams for the development of next-generation propulsion systems. The project includes tasks for main propulsion systems, orbital maneuvering system/reaction control systems (OMS/RCS), upper stages, main engines, and propellant management. Prototype hardware testing is scheduled for the 2004-2006 timeframe. Flight main engine design will be initiated in 2003 and will progress to Preliminary Design Review (PDR), at which time the 2nd Generation RLV program will make a decision for full-scale development.

NASA Unique: This activity is focused on the development of technologies for cargo carriers, rendezvous and docking systems, crew escape systems, and crew situational awareness. The initial solicitation process awarded two contracts under this task area. Additional contracts were awarded in December 2001 to initiate studies in crew-survivability and crew-escape systems technologies.

Flight Demonstrations: Currently this area consists of two tasks awarded under NRA 8-30 and the X37 project. The primary focus of the flight demonstrations project is the advancement and risk reduction of architecture enabling technologies: thermal protection systems, IVHM, flight operations, flight mechanics, and automated rendezvous. Successfully completed a series of X-40A flight tests and delivered the X-37 lower-fuselage assembly to Palmdale.

Program Documentation has been developed consistent with Agency Requirements, Program Plan, Level I Requirements Document, and Project Plans for all Technical areas, Risk Management Plan, and Systems Requirements Review documents.

Project Level Risk Reduction Reviews (RRR) will be conducted as an integral part of the IATR. The RRR will provide an integrated summary and status of the risk reduction activities performed by the industry partner for each technical task area.

The Interim Architecture Technology Review (IATR) is scheduled to conclude in March 2002. This activity will provide the basis for future architecture and technology decisions.

PROGRAM PLANS FOR FY 2003

The Space Launch Initiative plans to complete its Systems Requirements Review (SRR) in November 2002. This is the next step in the integration and synthesis of NASA, Industry and potential DoD requirements. This important review will result in more focused attention on fewer space transportation architectures and technology areas. .

Another Request for Proposal release is planned for February 2003, with contract awards planned for September 2003. This RFP is the next major milestone in the SLI process of focusing on architectures and technologies required to increase the safety and decrease the cost of space transportation systems. The solicitation will select the most promising architecture(s) to proceed toward a detailed preliminary design of competing 2nd Generation Reusable Launch Vehicle designs.

The program is executing the critical propulsion technology maturation as identified in NASA's prior Space Transportation Architecture Studies. To significantly increase the safety and reliability of space transportation systems and reduce their development and operational costs, the propulsion project is aggressively pursing multiple system concepts:

1) The Pratt and Whitney COBRA (Co-Optimized Booster Reusable Application) is a LOX/LH2 prototype engine with a single liquid/liquid fuel-rich preburner. The COBRA Engine Prototype Preburner Test Readiness Review will occur in December 2002, followed by the powerhead Test Readiness Review in March 2003 and the prototype engine system Critical Design Review in September 2003.

2) The Boeing/Rocketdyne RS-83 is a Fuel-Rich Staged Combustion (FRSC) engine design utilizing high-pressure turbopumps with integral low-pressure pumps and a gas/liquid main injector. Beginning in October 2002, the prototype engine Preliminary Design Review will be conducted followed by the Critical Design Review in June 2003. Subsystem level testing will begin in February 2003 with the Integrated Powerhead Demonstration test series and continuing forward with preparation for the Cross Feed system test later that year.

Propulsion development for vehicle on-orbit maneuvering and control systems will be initiated in November 2002 with the Technology Readiness Review of a two new auxiliary propulsion system (APS) designs: Lox/Ethanol and Lox/LH2. A prototype system will undergo a Critical Design Review in July 2003. These propulsion milestones will be subject to change pending the results of the IATR.

The Flight Demonstration project will greatly contribute to the program goals by servicing the needs of the technology projects through ground and flight demonstrations. Among the flight platforms, the **X-37 Approach and Landing Test Vehicle (ALTV)** will continue toward vehicle roll-out in early FY 2004 with the successful end-to-end hardware and software integration and testing. The ALTV will demonstrate critical autonomous approach and landing technologies as well as validate vehicle aerodynamics for the orbital X-37 vehicle.

The SLI program has also identified the need to develop the capability for the 2nd Generation RLV to perform autonomous rendezvous and proximity operations around a target vehicle such as the International Space Station. This capability will greatly reduce the cost of vehicle operations while on-orbit by reducing the manpower associated with proximity operations and docking. The **Demonstration of Automated Rendezvous and Technology (DART)** project, if selected beyond the base period of the current contract in CY 2002, will continue toward the launch of an orbital vehicle in FY 2004 with final hardware and software integration and testing followed by the Systems Acceptance Review. This vehicle will demonstrate the guidance, navigation, and control software and hardware sensors necessary to autonomously operate and rendezvous with a passive target vehicle. Multiple vehicle approach methods will be demonstrated as well a simulated Collision Avoidance Maneuver.

Vehicle Airframe Technology activities will continue in FY 2003 with the integration of an advanced **Integrated Vehicle Health Monitoring (IVHM)** sensor with completion of corresponding structural analysis algorithm development. Later in the year, this sensor will undergo actual flight tests to validate sensor performance. Also undergoing extensive thermal modeling and analysis is the Ultra High Temperature Ceramic (UHTC) thermal protection system. This material has been developed to reduce thermal loading experienced on a vehicle during orbital reentry without adding additional weight. A new high temperature Ceramic Matrix Composite (CMC) material, for protecting "sharp edged" flight control surfaces will also be evaluated this year.

Vehicle **Propellant Tank** development activities will proceed with component level tests of new tank joint concepts. The test results will lead to new joint designs enabling dissimilar materials and geometries to be joined for strength while eliminating leaks. Finally, results of these tests will lead to specifications for new cryogenic tank designs as well as developing engineering tolerances and post-flight inspection requirements.

Vehicle **Flight Operations** research and development in FY 2003 will gain a new "smart" umbilical quick disconnect (QD) prototype. This connector will allow automated connections of the vehicle to service facilities, thereby eliminating risk to service personnel, speeding operations and reducing overall costs. Innovative design concepts for ground equipment, which produce increased propellant density and performance, will undergo formal design review. The documented results will provide the foundation for the more detailed Critical Design Review (CDR) to follow later in the program.

In May of FY 2003, the **Flight Mechanics** project will test and demonstrate an interim release of advanced mission design software. This software technology is crosscutting as it applies to all vehicle architectures currently being investigated. A successful demonstration will advance the state-of-the-art by performing end-to-end mission design and automated flight software and mission-load generation, thus greatly reducing the operations cost currently associated with software development and mission design.

(Budget Authority in Millions of Dollars)

X-37 – LIFE CYCLE COST (LCC)	**PRIOR**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**TOTAL**
X-37 ACTIVITIES	95.5	26.0	22.1	0.0	0.0	0.0	0.0	143.6
TOTAL (EXCLUDES CIVIL SERVICE COST ($M)	95.5	26.0	22.1	0.0	0.0	0.0	0.0	143.6
(ESTIMATED CIVIL SERVICE FTEs	202	70	40	0	0	0	0	312
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	19.1	6.7	3.8	0.0	0.0	0.0	0.0	29.6

BASIS OF FY 2003 FUNDING REQUIREMENT

SPACE TRANSFER AND LAUNCH TECHNOLOGY (STLT) PROGRAM

Web Address: http://www.spacetransportation.com/ast/astp.html

	FY 2001	FY 2002	FY 2003
		(Millions of Dollars)	
STLT PROGRAM	**101.8**	**111.0**	**120.2**
Rocket-Based Combined Cycle Project	20.4	29.4	37.2
Turbine-Based Combined Cycle Project	14.1	10.2	20.4
Hypersonics Flight Demonstrator Project (X-43C)	--	15.2	28.0
Revolutionary Technology	67.3	56.2	34.6
In-Space (Included above: Transfers to Space Science in FY02).	[9.7]	--	--
Construction of Facilities (Included above)	[12.0]	[18.0]	[4.0]

DESCRIPTION/JUSTIFICATION

The Space Transfer and Launch Technology (STLT) will pioneer the identification, development, verification, transfer, and application of high-payoff space transportation technologies. STLT is responsible for implementing the 3rd generation (Hypersonics) element of NASA's Integrated Space Transportation Plan. Other elements of the STLT are responsible for implementing in partnership with the Department of Defense long-term Reusable Launch Vehicle (RLV) research and space Science-funded In-Space technology developments. As a result of NASA's participation in the National Hypersonics Plan development, NASA has focused its 3rd Generation Reusable Launch Vehicle efforts on the unique, critical technologies required to meet these ambitious goals. The refocused efforts are centered around integrated ground demonstrations of rocket based combined cycle systems, turbine based combined cycle systems and flight demonstration of high speed scramjet propulsion/airframe integration.

STLT will conduct research and develop technologies that will provide the greatest total safety improvements and cost savings over the life cycle of a space transportation system or the life span of approved missions that would utilize that transportation system. The STLT will seek to advance technologies that enable missions that are currently not technically or economically feasible. These missions include airline-like earth-to-orbit transportation (3rd Generation RLV's) to enable new commercial space markets, ensure seamless aerospace national security and enable the human exploration and development of space. Fulfilling NASA's role as an investment in America's future, the STLT is looking well beyond the immediate space missions at hand, further toward routine access with airline-like operations along a vastly enlarged highway to space.

STLT is responsible for cross cutting research, technology development and demonstrations that provide revolutionary technology products that support internal and external customer needs. Technology maturity will be measured using the NASA Technology Readiness Level (TRL) scale. First, STLT will develop a long term foundational technology "pipeline" through low TRL (1-3) research investments. These will primarily be executed through the Propulsion Research and Technology (PR&T) and Airframe Research and

Technology Projects and will have strong in-house and university participation. Second, STLT will develop and demonstrate technology at the component and subsystem level (TRL 4–5). These will also primarily be executed through the Propulsion Technology and Integration (PT&I) and Airframe Research and Technology Projects. Third, STLT will demonstrate technologies at the system level in high-fidelity, focused ground demonstrations (TRL 5–6). These will also be executed in the PT&I Project. Current investments include parallel systems demonstrations of Rocket Based Combined Cycle (RBCC) and Turbine Based Combined Cycle (TBCC) systems. Fourth, STLT will demonstrate technologies (where required) in relevant flight environments through focused experimental vehicles. A large-scale vehicle/propulsion demonstrator will ultimately validate these technologies in-flight. These will be executed in the Hypersonic Flight Demonstrators Project. Current activities are focused on demonstrating hydrogen and hydrocarbon scramjet engines in-flight (X-43C) and planning for potential future combined cycle flight demonstrations. Technology products will be transferred to internal and external customers at all levels of development.

STLT will advance the state of the art in propulsion systems for low-cost, reliable and safe earth-to-orbit space transportation. Furthermore, STLT will develop technologies that are focused on advanced, breakthrough technologies in air-breathing and rocket systems and cross cutting activities that are the basis for improvements in these disciplines. STLT objectives are to increase safety, reliability, and operability through robust designs and applications while reducing operations, manufacturing, and development costs through advanced design techniques and robust testing.

STRATEGIC OBJECTIVE:	**PROGRAM APPROACH:**
Advance Space Transportation - Mission Safety - Mission Affordability	STLT will use an incremental approach, which includes decision points for programmatic change and provides valuable demonstrations. This will be done in a three-pronged approach: system studies for vision vehicles, research and focused technology development, and incremental ground and flight demonstrations. System studies will screen many launch vehicle options at a low level of fidelity, and selected options at a high level of fidelity. These systems studies will address architectures including Single Stage to Orbit and Two Stage to Orbit; Horizontal Takeoff and Horizontal Landing and Vertical Takeoff and Horizontal Landing; hydrogen, hydrocarbon, and dual-fuel; and many other propulsion options. The ground and flight technology demonstrators are focused on air-breathing propulsion systems. By going to flight, these demonstrator vehicles will also include airframe systems critical to affordable hypersonic flight. Following the X-43C testing, scramjet development will continue, both for the hydrocarbon, and hydrogen fueled engines. Development of the HyTech engine will continue to improve its robustness. Additional efforts will focus on integration of this engine into combined-cycle and combination engine applications. Development of the hydrogen fueled scramjets system will concentrate on hyper-velocity (Mach 10-16) flight conditions and include scramjet-to-rocket mode transition. Flight demonstration may be performed using a rocket-launched liquid-hydrogen-

	cooled/fueled vehicle. Flight validation of the complete hypersonic systems will allow development of a 3rd generation launch vehicle for NASA, or military applications. Authority to proceed is scheduled for late in the next decade with initial operating capability in the decade after next. In addition, spin-off research and technology can support other hypersonic military applications, such as missiles and global-reach vehicles, as well as commercial hypersonic vehicles.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Advance Space Transportation
Strategic Plan Objectives Supported: Mission Safety, Mission Affordability
Performance Plan Metrics Supported: APGs 3R7, 3R9

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-03 Change	Comment
Composite Cryogenic Tank and Integrated Structures demonstration		7/01	11/00	Complete	
RBCC Demonstrator conceptional design complete		9/01	11/00	Complete	
Initial Flowpath Definition & Testing Completed for RBCC Demonstrator		9/01	9/01	Complete	
ISTAR RBCC Demonstrator Systems Requirements Review (SRR) Completed	6/02	6/02	11/00		
Conduct RTA TBCC PRR and SRR	6/02	6/02	11/01		
Complete an external independent review of three revolutionary hypersonic propulsion technology systems demonstrations that include the RBCC, TBCC, and scramjet engines.	12/03	10/02	10/02	+3 months	Provide the time needed to ensure all concepts are be mature before review

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-03 Change	Comment
Complete the High Temp Composites Demonstration where significant weight reduction for RLV engine systems can be quantified through actual test data.	9/03	9/02	11/00	+12 months	Funding reprioritization delayed supporting technology development

Lead Center: Marshall Space Flight Center	**Other Centers:** Ames Research Center, Dryden Flight Research Center, Glenn Research Center, Johnson Space Center, Langley Research Center, Stennis Space Center	**Interdependencies:**
Projects	**Project Lead Center**	**Contractor / Location**
ISTAR RBCC	Marshall Space Flight Center	Boeing Rocketdyne Propulsion & Power / Canoga Park, Ca. Gencorp Aerojet / Sacramento, Ca. Pratt & Whitney / West Palm Beach, Florida
RTA TBCC	Glenn Research Center	Allison Advanced Development C0. / Indianapolis, Indiana GE Aircraft Engines / Endale, Ohio Pratt & Whitney / East Hartford, Ct Williams International / Walled Lake, Mi
X-43C	Langley Research Center	Allied Aerospace Industries Inc. (Micro Craft and GASL) / Tullahoma, TN and Ronkonkoma, NY Boeing Company / St Louis, MO and Long Beach, CA Pratt & Whitney / West Palm Beach, Florida
Program Product	**Builder (Location)**	**Product Benefit**
ISTAR RBCC	Boeing Rocketdyne Propulsion & Power / Canoga Park, Ca. Gencorp Aerojet / Sacramento, Ca. Pratt & Whitney / West Palm Beach, Florida	Develops rocket based, cutting-edge vehicle propulsion system utilizing propellants collected during flight
RTA TBCC	Allison Advanced Development Co. / Indianapolis, Indiana	Develops turbine based cutting edge vehicle propulsion system utilizing propellants collected during flight

	GE Aircraft Engines / Endale, Ohio Pratt & Whitney / East Hartford, Ct Williams International / Walled Lake, Mi	
X-43C	Allied Aerospace Industries Inc. (Micro Craft and GASL) / Tullahoma, TN and Ronkonkoma, NY, Boeing Company / St Louis, MO and Long Beach, CA, Pratt & Whitney / West Palm Beach, Florida	Demonstrates cutting edge vehicle propulsion system utilizing propellants collected from rarified atmosphere during flight

PROGRAM STATUS/NOTIFICATIONS/PLANS THROUGH 2002

The initial flowpath definition and concept design iteration for the ISTAR RBCC demonstrator was also completed during September 2001. The initial flowpath definition was used as criteria for the ISTAR RBCC demonstrator engine selection.

The **Hypersonics Flight Demonstrator** project initiated the development of the X-43C concept in 2001. With project requirements defined, vehicle design candidates were proposed and the Vehicle Advanced Studies and Conceptual Design Contract was awarded. In addition, the project successfully completed the Composite Cryogenic Tank and Integrated Structures Demonstration, meeting a program-level milestone and resulting in significant weight reduction for RLV cryotanks. A five-month, $1.3M conceptual design effort resulted in a revised configuration, yielding improved performance and increased margins. A Project Requirements Review (PRR) and Interim Design Review (IDR) were also completed.

The **ISTAR RBCC** project achievements included the first ever trajectory simulation of an RBCC flowpath, transitioning from air-augmented rocket, to ramjet, to scramjet modes in a single test and sea-level static testing of Aerojet strutjet flowpath rocket thrusters. Pursuing flight demonstration of an RBCC engine system as the next logical step in combined cycle propulsion development, the ISTAR RBCC Project completed a major system study effort to help select an industry RBCC concept. The Aerojet strutjet concept was selected by this study for initial ISTAR RBCC development activities, successfully reaching the milestone for Initial Flowpath Definition for the RBCC Demonstrator. In 2001, accomplishments for the ISTAR Project included the Preliminary Requirements Review (PRR) and Conceptual Design Review (CoDR), successfully achieving mixing test requirements. System analyses were completed which resulted in a decision to use hydrogen peroxide as oxidizer for the demonstrator engine. In November, contract was awarded for the completion of the conceptual design activity to an industry consortium, RBC^3, consisting of Boeing Rocketdyne, Gencorp Aerojet, and Pratt & Whitney. The Systems Requirements Review (SRR) for the RBCC Demonstrator Engine will be completed in FY 2002.

In 2001, the **RTA TBCC** Project successfully completed an initial round of airframe and propulsion systems studies to evaluate potential TBCC concepts that show promise for meeting the ASTP goals for cost and safety. Specifically, a Two Stage To Orbit (TSTO) vehicle trade study was completed which determined TBCC thrust and speed requirements for a vehicle concept that was projected to have acceptable weight limits. A Mid Term Review (MTR) was held in July 2001 to review the four TBCC concepts that are being developed by the turbine engine manufacturers: General Electric, Pratt & Whitney, Williams International, and Allison Advanced

Development Company. These paper evaluation studies currently being performed will lead to an FY2002 downselect to the preferred approach for follow-on technology development and demonstration in the out years of the ASTP Program. Magnetic bearings have been identified to be an enabling technology for all TBCC approaches. In FY 2002, an initial test of a magnetic bearing concept was completed at NASA Glenn Research Center. This test demonstrated that the requirements for temperature, thermal cycles, and hours of operations could be met. Major events to be completed in FY 2002 will be the Preliminary Requirements Review (PRR) and Systems Requirements Review (SRR).

PROGRAM PLANS FOR FY 2003

In FY 2003, STLT will demonstrate advanced adhesives for non-autoclave composite processing where significant manufacturing cost reduction will be demonstrated. Additionally, STLT will complete an external independent review of the three revolutionary hypersonic propulsion technology systems demonstrations that include the RBCC, TBCC, and scramjet engines. Other achievements will include the High Temperature Composites Demonstration where significant weight reduction for RLV engine systems can be quantified through actual test data.

BASIS OF FY 2003 FUNDING REQUIREMENT

COMPUTING, INFORMATION AND COMMUNICATIONS TECHNOLOGY (CICT) PROGRAM

Web Address: http://www.cict.nasa.gov/

	FY 2001	FY 2002	FY 2003
		(Millions of Dollars)	
CICT Program	**165.6**	**155.9**	**154.0**
Intelligent Systems	53.8	63.8	79.7
Computing, Networking and Information Systems	50.2	44.2	37.0
Space Communications	19.2	9.1	7.6
Information Technology Strategic Research	42.4	38.8	29.7

DESCRIPTION/JUSTIFICATION

The CICT Program will research, develop, and use advance computing, information, and communications technologies to allow NASA to accomplish its commitments to United States taxpayers with greater mission assurance, for less cost, and with increased science return. CICT research and development, as an integral element of the Federal information technology investment, will also act as a catalyst for continued national excellence in information technologies.

Through its Strategic Plan, NASA has made the following commitments:

- To advance and communicate scientific knowledge and understanding of the Earth, the solar system, and the universe;
- To advance human exploration, use, and development of space; and
- To research, develop, verify and transfer advanced aeronautics and space technologies.

In order to achieve these commitments, NASA must accelerate the infusion of new technologies and capabilities into its future missions. The Aerospace Technology Enterprise plays a fundamental role in achieving NASA's mission through the identification, development, verification, transfer, and commercialization of high-pay-off aerospace technologies. Within this role, the Enterprise seeks to pioneer basic research in revolutionary technologies, including information technology, nanotechnology, and biotechnology. The CICT Program supports the Enterprise's role by directly addressing the strategic goal of the Enterprise to pioneer technology innovation and its following objectives:

- Develop advanced engineering tools, processes, and culture to enable rapid, high-confidence, and cost-efficient design of revolutionary systems
- Develop revolutionary technologies and technology solutions to enable fundamentally new aerospace system capabilities and missions

To address these objectives, the CICT Program has established a Program goal to enable NASA's scientific research, space exploration, and aerospace technology missions with greater mission assurance, for less cost, and with increased science return through the development and use of advanced computing, information and communications technologies. Four Projects of CICT will meet this Program goal:

The **Intelligent Systems Project** will enable smarter, more adaptive systems and tools that work collaboratively with humans in a goal-directed manner to achieve NASA's twenty first century mission/science goals, including:

- Robotic exploration of deep space;
- Combined human-robotic exploration of Mars;
- Safe and cost effective operation of the Space Shuttle and follow-on launch vehicles;
- Use of Earth-orbiting satellites to establish cause and effect relationships associated with such important phenomena as global warming;

The **Computing, Networking and Information Systems Project** will enable seamless access to ground-, air-, and space-based distributed hardware, software, and information resources to enable NASA missions in Earth, Space and new Aerospace Technology capabilities.

Through seamless access to NASA assets, scientists and engineers will be able to focus on making new discoveries in science, designing the next generation space vehicle, controlling a mission or developing new concepts for the National Airspace system rather than on the details of using specific hardware, software and information resources.

The **Space Communications Project** will enable broad, continuous presence and coverage for high rate data delivery to users from ground-, air-, and space-based assets directly.

High rate data delivery is an enabling technology for NASA's twenty-first century missions, including:

- The Earth Science Enterprise Digital Earth Vision, in which all observing spacecrafts are in a distributed network to provide real–time multi-sensor information transfer directly to users.
- The HEDS Enterprise missions requiring multi-gigabit Internet-based communications in near-Earth orbit.
- The Space Science Enterprise missions requiring high rate communications from scientific spacecraft traveling to our outer planets and beyond in addition to intra-planetary networks for surface exploration.

The **Information Technology Strategic Research Project** will research, develop, and evaluate a broad portfolio of fundamental information and bio/nanotechnologies for infusion into future NASA missions.

Many of the missions in NASA's future will rely on technologies that are new and dramatically different from those in current practice today. The challenges of deep space exploration, hostile environments, and remote science create a need for new technologies that employ new materials, smaller, lighter, and less power consuming devices, highly reliable software and reconfigurable computing and information technologies.

In addition to these four Projects, two additional Projects are envisioned for initiation in the 2005 fiscal year following successful evaluations during the later part of the 2003 fiscal year of key predecessor technologies and capabilities. These two Projects are Systems Autonomy and Information Grid Systems. Based on successful development of key component autonomy technologies from the Intelligent Systems Project, the Systems Autonomy Project will conduct the research and development necessary to integrate various ground-based and on-board autonomy components into a fully integrated system. Meanwhile, the Information Grid Systems Project will build upon the advances in ground-based and space-based computing and networking advances to ultimately provide a seamless information environment for NASA's exploration and science missions.

By integrating and applying focused leadership to the Agency's information technology investments, the CICT Program will make coordinated and cost-effective strategic investments in fundamental computing, information and communication technology advancements required to enable and enhance a broad class of future NASA missions. The CICT Program will work closely with other NASA programs to ensure that relevant technologies are pursued for NASA missions.

STRATEGIC OBJECTIVE:	PROGRAM APPROACH:
Pioneer Revolutionary Technology - Engineering Innovation - Technology Innovation	Develop and demonstrate revolutionary computing, information and communications technologies in the specific areas of autonomy, human-centered systems, intelligent data understanding, advanced computing and networking, information environments, and fundamental information, bio- and nano-technologies. Integrate and transfer these new technologies into aerospace system capabilities and missions.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Pioneer Revolutionary Technology
Strategic Plan Objectives Supported: Engineering Innovation, Technology Innovation
Performance Plan Metrics Supported: APGs 3R11, 3R12

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-03 Change	Comment
Combine propulsion controlled aircraft (PCA) control laws with the intelligent flight control system (IFCS)		3/01	3/01	Complete	Conducted a full flight simulation demonstration of integrated PCA and IFCS for a representative transport aircraft. Ability to control and land aircraft with significant control surface failures has been demonstrated.

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-03 Change	Comment
Develop system software tools and techniques to enhance application performance		6/01	6/01	Complete	Demonstrated software tools to reduce parallelization time from months to one week while maintaining 50% application performance compared with manual parallelization
Develop tools and techniques to measure computing and communication capabilities		9/01	9/01	Complete	Demonstrated execution benchmarks (aerodynamic shape optimization for 3-dimensional transonic wing) implemented on nonlinear potential (TOPS) and Navier-Stokes flow solvers (ARC2D)
Adapt application codes for high performance testbed		9/01	9/01	Complete	Parallelized three relevant application codes and documented evaluation of parallelization tools. 3X performance in applications for aerospace through the integration of networking enhancements into application codes.
Demonstrate advanced networking tools and techniques on NASA mission-oriented applications		9/01	9/01	Complete	Demonstrated 3 applications inter-operating on multiple QoS enabled networks; 50Mbps (aggregate internal) multicast; gigabit performance between 2 NASA sites; and 2 applications utilizing enhanced hybrid networking
Research and Education Network (NREN) Project closeout.		9/01	9/01	Complete	Technology advances achieved in the Research and Education Network (NREN) Project were archived and documented for use by other programs.
Computational Aerospace Sciences (CAS) project closeout.		9/01	9/01	Complete	Technology advances achieved in the Computational Aerospace Sciences (CAS) project were archived and documented for use by other programs.
Develop and apply technologies to measure and enhance performance on high-performance computing testbed.		9/01	9/01	Complete	Demonstrated improvements on the parallelization of 6 aerospace analysis and design codes. Improved automated parallelization techniques to achieve at least 50% efficiency improvements over manual parallelization techniques.
Successfully complete reviews of the Intelligent Systems Program by External Technical Review Council and Mission Needs Council.		9/01	9/01		Partially completed. External Technical Review Council reviews conducted. Mission Need Council review cancelled and to be addressed in CICT Program Review planning.
Demonstrate a prototype data communications scheme for the National Airspace System.		9/01	9/01	Complete	Flight demonstrated (DC-8) communications architecture capable of secure multi-priority and multi-channel digital information transfer for future National Airspace System communications.

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-03 Change	Comment
Demonstrate remote connectivity to high data-rate instruments and distributed real-time access to instrument data.		9/01	9/01	Complete	Demonstrated remote connectivity to NASA experimental facilities and University laboratory/ instruments. Demonstrated 50Mbits communication rates functioning on distributed computing architecture.
Develop a combinatorial chemistry approach to define optimum catalyst composition for carbon nanotube growth coupled with an electrical field enhanced nanotube alignment approach.		9/01	9/01	Complete	Developed an approach for nanotube growth and alignment that was validated with the successful growth and alignment of a nanotube.
Demonstrate tools capable of directly verifying aerospace software with minimal effort and demonstrate 10-time improvement over baseline state of practice using the Mars Pathfinder Code		12/01	12/01	Complete	Demonstrated use of static analysis techniques to identify code errors and inconsistencies not detectable through standard compilation procedures. Use of this technique will reduce the requirements for time-consuming testing to detect and isolate these errors.
Complete a case-study demonstrating software verification and validation techniques that are applicable to Mars mission software, and benchmark current state-of-the-art.	6/02	6/02	6/02		
Develop and demonstrate in flight next-generation neural flight control technologies for aircraft and reusable launch vehicles.	6/02	6/02	6/02		
Participate as part of the MER 2003 flight team applying human-centered computing analysis and modeling techniques to evaluate and improve man-machine system performance for operations and science.	8/02	8/02	8/02		

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-03 Change	Comment
Develop conceptual high-level autonomy architecture for rovers collaboratively between Ames, JPL, CMU and other partners	8/02	8/02	8/02		
Demonstrate improvement in time-to-solution for aerospace applications through high-end computing and end-to-end networking capabilities.	9/02	9/02	9/02		Planned efforts have been updated based on program planning, prioritization and reorganization. Efforts will be integrated with CICT Exploratory Grid Environment milestone in 9/02
Demonstration of Space Communication Link Technology Operating at 622 Mega-bit per second for Direct Space Data Distribution to Users	9/02	9/02	9/02		
Design, fabricate and evaluate carbon nanotube electronic devices	9/02	9/02	9/02		
Human-centered computing Mars exploration rover study: Complete initial task analysis of planned Mars'03 mission operations	9/02	9/02	9/02		
Develop an exploratory grid environment that supports location-independent use of heterogeneous data sets and high confidence tools.	9/02	9/02	9/02		
Demonstrate the capability to perform pilot-in-the-loop redesign for an Enterprise-relevant aerospace vehicle design effort during a single test entry in a flight simulation facility using integrated, CFD, flight test, and wind tunnel data.	9/02	9/02	9/02		

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-03 Change	Comment
Demonstrate feasibility of nanotechnology-based chemical and biosensors and of manufacturing approaches for low-power nanoelectronic components.	9/02	9/02	9/02		
Demonstrate distributed analysis and data processing to support new problem solving paradigms.	6/03				
Discover a novel feature in skewed data using advanced data mining and feature extraction technologies	7/03				
Demonstrate individual autonomy component technologies to be included in a larger, integrated demonstration for the Mars smart landing mission	8/03				
Demonstrate very high power microwave sources to achieve 2 to 3 times increase in data transmission from Mars to Earth and as well as 10 times from Earth orbit to ground for the Mars smart landing mission	9/03				
Development and demonstration of molecular-electronics based chemical sensor technology for environmental health monitoring.	9/03				
Demonstrate certifiable program synthesis technology for verification and verification of advanced software for autonomy and aerospace vehicle control	9/03				

Lead Center: Ames Research Center	**Other Centers:** Dryden Flight Research Center, Glenn Research Center, Goddard Space Flight Center, Jet Propulsion	**Interdependencies:** NASA Space Science, AST, Earth Science, BPR, and HEDS Enterprises

	Laboratory, Johnson Space Center, Kennedy Space Center, Langley Research Center, Marshall Space Flight Center	
Project	**Project Lead Center**	**Industry Contractor (Location):**
Computing, Networking and Information Systems (CNIS)	Ames Research Center	
Space Communications	Glenn Research Center	
Intelligent Systems	Ames Research Center	
Information Technology Strategic Research	Ames Research Center	
Product	**Builder (Location):**	**Product Benefit**
Automated Reasoning	NASA in-house, multi-contractor and university effort	Autonomous science exploration missions that achieve high-level goals without instruction from human controllers
Human-Centered Systems	NASA in-house, multi-contractor and university effort	Technology which will allow for the elimination of at least one shift of operators for planetary exploration missions
Intelligent Data Understanding	NASA in-house, multi-contractor and university effort	Automatically discovery of new feature in large, distributed, heterogeneous database
Computing and Networking Environments	NASA in-house, multi-contractor and university effort	Technologies enabling ground-based and hybrid space/terrestrial computational grid
Information Environments	NASA in-house, multi-contractor and university effort	Integrated and collaborative environments for problem solving, research, and information management
Component Space Communications Technologies	NASA in-house, multi-contractor and university effort	Greater than 622 Mbits/second for near-Earth missions and 8 times the current data rate capability for planetary or deep-space missions
Space Communications Architecture	NASA in-house, multi-contractor and university effort	Architectures based on asymmetric heterogeneous networks designed for 50% coverage of Earth and planetary missions of Earth and planetary surfaces
Fundamental Info-, Bio- and Nano-Technologies	NASA in-house, multi-contractor and university effort	New bio, nano, or information technologies appropriate for transfer to another NASA program or project, or insertion into a NASA mission

PROGRAM STATUS/PLANS THROUGH 2002

In FY 2002, the **Computing, Information and Communication Technologies (CICT)** Program will continue to develop a seamless distributed computing and information system to support increased fidelity and reduced time-to-solution for NASA applications. Specifically, the CICT Computing Network and Information Systems (CNIS) Project will demonstrate key capabilities within relevant NASA aerospace design activities, including advanced space transportation vehicles research problems executed on an operational NASA communications grid. The NASA grid will represent an exploratory grid environment for location-independent utilization of data, computing assets, and high-confidence tools. Building upon previous advances in the integration of flight simulation capabilities into the design environment, CICT CNIS will also demonstrate the capability to perform pilot-in-the-loop redesign of an Enterprise-relevant aerospace vehicle during a single test entry in a flight simulation facility using integrated, CFD, flight test, and experimental data. Earlier, a prototype system was developed to demonstrate the feasibility and viability of this capability, which will enable the real-time evaluation and analysis of performance and handling characteristics from pilots for assessing aerospace vehicles that don't yet exist. Extending computing and communications into space, CICT Space Communications will advance high-end networking for NASA's future needs through the demonstration of Space Communication Link Technology operating at 622 Mega-bit per second. This will represent a dramatic improvement in the amount of data that can be transmitted and returned for scientific analysis and research.

In the CICT Intelligent Systems (IS) Project, FY 2002 will see the completion of major steps towards autonomous science exploration, including the development of the conceptual high-level autonomy architecture for planetary rovers. Collaborations have been formed with the Mars 2003 mission team to demonstrate the benefits of advanced planning and scheduling technology for automated sequence generation. The technology will be integrated into existing tools to be used by the mission and will be considered for incorporation into the mission following the demonstration. This effort is expected reduce by a factor of four the total amount of time required to generate an initial rover command sequence, allowing increased interaction between the science and engineering teams while also increasing the overall robustness of the sequence generation process. A human-centered computing study of planned Mars 2003 mission operations will provide valuable feedback and information for efficiency improvements in mission operations. CICT IS will also develop tools to improve the verification of autonomous software. A demonstration will be performed on aerospace software that will show a factor of 10 improvements in the time required to identify and isolate coding errors. This capability will also be exercised and validate on the Mars Pathfinder code. Later in the fiscal year, these tools and techniques will be further extended and will be applicable to future Mars mission software.

The CICT Information Technology Strategic Research (ITSR) Project will be making advances in the area of next-generation neural flight control technologies. These technologies will improve the safety and reliability of aircraft, and reduce the cost of control development for future aerospace vehicles. In FY 2002, CICT ITSR will also develop methodologies for producing revolutionary devices and structural materials by exploiting the interface between biotechnology and nanotechnology. Research will focus on creation of devices that exploit physical phenomena at the atomic/molecular level. Emphasis will be placed on the creation of nanoelectronic devices, as well as on increasing production of single-wall carbon nanotubes and on characterizing the first-order behavior properties of carbon nanotube materials. The feasibility of molecular level sensors and manufacturing approaches for low-power components will lead to the development and demonstration of a nanosensor in FY 2003.

Finally, the National Research Council's Aeronautics and Space Engineering Board will evaluate the ECT Program for research performer quality, technical and program quality, and customer relevance in FY 2002.

PROGRAM PLANS FOR FY 2003

In FY 2003, the **CICT Program,** through its CNIS Project will extend the capabilities of the NASA Communications Grid Environment through the demonstration of distributed analysis and data processing to support new problem solving paradigms. Specifically, the NASA Grid will be enhanced to address multi-Enterprise applications including demonstrations of key relevant aerospace and Earth science applications. CICT Space Communications (SC) will complete the development of ad-hoc space communications networks. This in-space networking capability will vastly improve science return by enabling the deployment of on-demand networking protocols in support of NASA's space and planetary exploration assets and inter-spacecraft communications. Very high power microwave sources will be demonstrated by the CICT SC Project to achieve a two- to three-fold increase in data transmission from Mars to Earth and as well as ten-fold increase from Earth orbit to ground. Power sources will be based on advance design of high power traveling wave tubes and semiconductor power amplifiers. These sources may be used as early as 2005 for Mars mission communications.

FY 2003 advances from the CICT Intelligent Systems Project will include a major demonstration of tools and techniques for intelligent data understanding. Specifically, feature recognition algorithms will be completed enabling the capability to automatically discover a novel feature within a skewed dataset. This will greatly enhance the capability to extract information and knowledge from the vast amounts of observational science data from Space Science and Earth Science missions. FY 2003 will also see significant advances in the development of autonomy technologies for NASA missions through the simulation of an autonomous science exploration mission. In particular, the demonstration of autonomous components operating independently during a mission simulation will be completed in FY 2003

In FY 2003, the CICT ITSR Project will develop efficient algorithms for automated generation of software designs and code, from requirements and specifications. This will include the development of program synthesis (or auto-coding) technology that enables product-oriented certification, rather than certification for flight based on traditional methods. This development will represent a significant advancement in the ability to certify and implement advanced software concept in mission critical systems. Also from ITSR, advances in Bio-Nanotechnology will see the development and demonstration of molecular-electronics based chemical sensor technology for environmental health monitoring. Additional future applications of this technology would include remote science exploration and sensor arrays.

BASIS OF FY 2003 FUNDING REQUIREMENT

ENABLING CONCEPTS AND TECHOLOGIES PROGRAM

	FY 2001	FY 2002	FY 2003
		(Millions of Dollars)	
Enabling Concepts and Technologies Program	**112.4**	**92.8**	**92.9**
Energetics	33.9	20.31	21.6
Advanced System Concepts	6.0	13.0	12.0
Advanced Spacecraft and Science Components	32.6	19.5	19.3
Space NRA's	39.9	40.0	40.0

DESCRIPTION/JUSTIFICATION

The spectrum of potential NASA missions identified by science and exploration enterprises far exceeds NASA's ability to execute them using known technology. These missions span the understanding of the Earth as a system, probing the nature of the Sun and its interactions with the Earth, exploration of Mars and the other planets of the Solar System, and seeking the origins of the Universe and life within it. The scope and depth of the knowledge sought far exceeds the capability and affordability of NASA to deliver it. Revolutionary technologies are needed to enable missions that are currently technically infeasible or economically impractical.

The Enabling Concepts and Technologies (ECT) Program pioneers the identification, development, verification, transfer, and application of high-payoff aerospace technologies that are applicable across many types and classes of systems needed to accomplish NASA's missions. It is the front end of the enabling technology pipeline that feeds the focused technology development programs of the Enterprises. In FY 2003, the ECT Program encompasses the spacecraft systems and science instruments parts of the former Cross-Enterprise Technology Development Program (CETDP), adds a new advanced systems effort to guide technology investments, and introduces new incentives for transition of technologies to customer applications. The program invests in potentially high pay-off technologies that may involve considerable risk to achieving successful or rapid development.

The charter of the ECT Program is to provide revolutionary technologies that can enable NASA's strategic visions and expand future mission possibilities. The ECT Program provides fundamental research in advanced mission system concepts coupled with high-payoff spacecraft component technologies such as micro-electronic and mechanical systems (MEMS), high performance materials, and nanotechnology to stimulate breakthroughs that could enable new system concepts. Three technology development projects have been formulated to accomplish ECT Program objectives.

The **Advanced Systems Concepts Project** performs conceptual studies and systems analysis of revolutionary aerospace systems and concepts that have the potential to leap well past current plans, or to enable new visions for NASA's strategic plans. NASA Enterprise customers participate in these studies and provide input on system needs for requirements. Potentially enabling breakthrough technologies are examined in mission models and aggregated benefits of technology investments across multiple missions and mission classes are evaluated.

The **Energetics Project** seeks to develop advanced energetics technology to provide power and propulsion for enhanced mission capabilities and to enable missions beyond current horizons. NASA Enterprise customers provide inputs on system needs and requirements and regularly participate in reviews of the relevance of Energetics investments to their missions. Its technology foci include solar power generation, energy conversion and storage, power management and distribution, on-board spacecraft propulsion, and nuclear-electric concepts.

The **Advanced Spacecraft and Science Components Project** addresses advanced technology for sensing and spacecraft systems to enable bold new missions of exploration and to provide increased scientific return at lower cost. NASA Enterprise customers provide inputs on system needs and requirements and regularly participate in reviews of the relevance of Advanced Space and Science Components investments to their missions The project emphasizes advanced spacecraft and instrument systems technologies, including miniaturized sensors, micro-spacecraft components and subsystems, advanced active instruments, distributed spacecraft and sensor systems, resilient materials and structures, multifunctional and adaptive structures, space environment models, and analytical tools to predict environmental effects.

Two future projects, expected to start in FY 2005, Multi-Technology Integrated Systems, and Revolutionary Space Flight Research, will integrate advanced technology products from multiple projects into proof-of-concept systems to identify technical issues, to mature designs, and to validate performance in applications that will benefit future NASA missions.

The ECT Program departs significantly from past practice in NASA cross-enterprise technology programs that funded the delivery of a technology to a specific readiness level, and left it to chance as to whether it would reach end users. Instead, approximately 50 percent of ECT Program funding will be allocated for transition and insertion of technology products into the focused technology development and validation programs of Enterprises. Customer investment is required for the transition and insertion phases and is sought through negotiation with mission technology developers and competitive proposals to customer solicitations. Progress of tasks toward transition or insertion is considered in annual program reviews. Failure to attract partnerships for follow-on phases leads to a termination review in which the viability of continuing tasks without further customer investment is determined.

The ECT Program will develop systems analysis of mission classes to identify high-payoff technology areas and to establish performance goals for technology products in representative mission applications. In the exploration phase, systems analysis will be used to guide the selection of new tasks, and to assess the potential benefits of technology products currently under development relative to the state-of-the-art. In the transition phase, systems analysis will be used to prioritize areas for continued investment.

Broadly announced peer-reviewed NASA Research Announcements (NRAs) and other competitive announcements are used to capture innovative ideas from external organizations and to augment emerging critical capabilities. In FY 2002, $47M, almost half of the funding for the ECT Program, was devoted to tasks originally selected through broadly announced NRAs. The Advanced Systems Concepts Project sponsors annual solicitations for revolutionary systems concepts via an NRA managed by the university-led NASA Institute of Advanced Concepts. The ECT Program continues in FY 2003 a set of 112 tasks awarded in FY 2001 under the

Advanced Cross-Enterprise Technologies NRA issued in 1999 by the Office of Space Science. These tasks, managed by the Advanced Spacecraft and Science Components Project and the Energetics Project, encompass a wide range of technical disciplines including power and propulsion, sensors and instruments, optics, structures and materials, robotics, communications, and advanced computing infrastructures. These research projects are scheduled for completion by the second quarter of FY 2004. In FY 2001 an additional NRA for advanced polymer battery technology and, in FY 2002, for advanced space environmental effects technology, were awarded that will continue through FY 2003. Beginning in FY 2003 and continuing yearly afterward, the program will release NRA or other broadly announced solicitations from the ECT projects to fund new multiyear developments and activities for award in FY 2004. The solicitations will exclude NASA Centers and JPL from participation in order to enhance opportunities for cooperation between the NASA Centers and all potential awardees that can lead to successful transition, integration, and insertion to missions. Approximately 75 percent of funds for new technology will be applied to this broad solicitation process in which NASA centers do not compete. Funding is included under this program for selected Congressional special interest initiatives identified in the FY 2002 Appropriations Act.

STRATEGIC OBJECTIVE:	**PROGRAM APPROACH:**
Pioneer Revolutionary Technology • Technology Innovation	Seek and develop advanced ideas and concepts in spacecraft and science systems to enable new observation and measurement capabilities, vast improvements in efficiency of on-board resources supplied coupled with significant decreases in on-board resources required by science and mission systems, and breakthrough concepts in materials properties, structural packaging, and functional integration that can significantly improve the launch efficiency of mission payloads. Technologies that are applicable to a wide set of mission classes are emphasized. New ideas are sought in broad public announcements and within NASA. After an initial exploration period, promising developments are down-selected for transitional maturation toward potential mission applications. Customer involvement in the selection and funding of the transitional phase is actively pursued.
Advance Space Transportation • Mission Reach	Develop revolutionary approaches to reduce the time required for planetary missions by advanced propulsion technologies such as electromagnetic, nuclear fusion, and beamed energy sources. New ideas are sought in broad public announcements and within NASA. After an initial exploration period, promising developments are down-selected for transitional maturation toward potential mission applications. Customer involvement in the selection and funding of the transitional phase is actively pursued.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Pioneer Technology Innovation, Advance Space Transportation
Strategic Plan Objectives Supported: Technology Innovation, Mission Reach
Performance Plan Metrics Supported: APGs 3R10, 3R12, 3R13

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-03 Change	Comment
Science Sensors and Detectors					
Demonstrate prototype 2.5 Terra-Hz local oscillator	1/03		1/03		
Demonstrate high-efficiency, tunable, narrow-line 2 micron laser transmitter for differential absorption LIDAR	7/03		7/03		
Large and Distributed Space Systems					
Demonstrate shape-memory-deployable composite boom	11/02		11/02		
Demonstrate shape-memory-deployable composite boom	11/02		11/02		
Demonstrate GPS-based multiple spacecraft attitude control for formation flying in a realistic environment	8/03		8/03		
Micro and Multi-Purpose Spacecraft Components and Systems					
Demonstrate proof-of-concept sun angle sensor on chip	5/03		5/03		
Power and Electric Propulsion Systems					
Demonstrate > 25% efficiency micro-ion engine	4/03		4/03		
Demonstrate feasibility of high efficiency (>30%) multi-band-gap solar cell on silicon substrate.	9/03		9/03		

Lead Center: Headquarters	**Other Centers:** Glenn Research Center, Goddard Space Flight Center, Jet Propulsion Laboratory, Langley Research Center, Marshall Space Flight Center	**Interdependencies:** NASA Space Science, AST, Earth Science, BPR and HEDS Enterprises
Project	**Project Lead**	**Contractors/Partners**
Energetics	Glenn Research Center	Ohio Aerospace Institute, Case Western Reserve University, over 20 universities and companies
Advanced System Concepts	Langley Research Center	NASA Institute of Advanced Concepts, Swales, Boeing
Advanced Spacecraft and Science Components	Headquarters	DARPA, NOAA, AFRL, over 40 universities and companies

Products	Developer	Project Benefit
New concepts for ultra-efficient spacecraft power and on-board propulsion	Glenn Research Center, Marshall Space Flight center, Jet Propulsion Laboratory, multiple contractors and universities	Significant spacecraft mass reduction, power and fuel efficiency increase, extended mission range and life
Revolutionary concepts for space mission systems	Langley Research Center, Jet Propulsion Laboratory, Goddard Space Flight Center, multiple contractors and universities	Identification of heretofore impossible or impractical missions enabled by revolutionary approaches and technologies
New concepts for ultra-compact and low power-draw spacecraft and instrument systems	Goddard Space Flight Center, Jet Propulsion Laboratory, Langley Research Center, Marshall Space Flight Center, multiple contractors and universities	Heretofore impossible or impractical science measurements and significantly reduced spacecraft power and launch volume/mass requirements

PROGRAM STATUS/PLANS THROUGH 2002

FY 2002 is a transition year for the **Enabling Concepts and Technologies (ECT)** Program. The Program is in the final year of scheduled development on approximately 200 three-year exploratory technology tasks in ten technology thrusts begun in FY 2000 under the Office of Space Science and the second year of approximately 115 exploratory tasks in the same ten themes awarded by NASA Research Announcements (NRA) in FY 2001. Investigators are distributed across university, industry, government and private laboratories, and NASA field Centers. Products being developed include a broad range of spacecraft and sensor devices that promise significantly reduced power and mass requirements, innovative antenna and optics concepts, and breakthrough concepts for energy generation and storage, and robotic exploration devices. In order to fully realize the value of the large number of technologies emerging from these exploratory studies, systems analyses are being devised to compute aggregated potential benefits of the technologies across NASA's mission classes. Mission technologists across NASA's enterprises are evaluating technology products from soon-to-be-completed tasks to determine where potential transition to mission application is warranted and whether further development of promising immature products for their needs is desired. In addition to the systems assessments and enterprise customer evaluations, the National Research Council Aeronautics and Space Engineering Board will evaluate the ECT Program for research performer quality, technical and program quality, and customer relevance in FY 2002.

PROGRAM PLANS FOR FY 2003

In FY 2003, the **ECT Program** will be restructured from the original ten themes into three projects that emphasize technologies to enable breakthrough capabilities in active science instruments, highly distributed, ultra-efficient and resilient space systems, and revolutionary mission systems studies. In response to the NASA Independent Assessment Team Report, a transition/insertion phase will be added to the ECT Program to address the difficult problem of assuring that new technology is advanced beyond the proof-of-concept stage to mission use. Beginning in FY 2003, a significant portion of program funds (eventually up to 50 percent) will be applied to advancing the most promising products from completed exploratory tasks for transition to mission applications based on customer and quality reviews and systems analyses performed in FY 2002. NRAs and in-house solicitations will be issued for the next phase of exploratory tasks for new ideas that can revolutionize NASA's mission capabilities with non-NASA awards comprising at least 75 percent of exploratory funding. Investment priorities will derive from FY 2002 systems studies and independent review results. Openly competed NASA Research Announcements (NRA) will be made and selections completed for award in FY 04 to replace the NRA tasks ending in FY 2003. Specific technology investments will include the following:

Advanced Systems Concepts Project - Revolutionary aerospace concepts selected annually through competitive NASA Research Announcements and internal competition. In-depth investigations of concepts down-selected from initial studies conducted in FY 2002 will be conducted. The renewal contract for operation of the NASA Institute of Advanced Concepts for external solicitation of advanced concepts will be openly competed.

Energetics Project - Advanced spacecraft energy production and storage systems including all-plastic batteries, long-life fuel cells, compact, high-speed flywheels, and advanced power management technologies. Advanced electric, electromagnetic, and nuclear propulsion technologies that offer the far term potential to revolutionize launch and orbital transfer.

Advanced Spacecraft and Science Components Project - Space-capable LIDAR instruments and efficient, long-life lasers to enable them; active sensor and focal plane concepts to enable new observation and measurement capabilities, formation flying control methods and spacecraft components to enable distributed instrument networks; and advanced multifunctional materials as well as spacecraft and instrument components that capitalize on their capabilities.

BASIS OF FY 2003 FUNDING REQUIREMENT

ENGINEERING FOR COMPLEX SYSTEMS (ECS) PROGRAM

Web Address: http:// dfs.arc.nasa.gov /

	FY 2001	FY 2002	FY 2003
		(Millions of Dollars)	
Engineering for Complex Systems Program	**- -**	**28.0**	**28.0**
System Reasoning & Risk Management	- -	9.7	9.1
Knowledge Engineering for Safe Systems	- -	5.4	4.9
Resilient Systems & Operations	- -	12.9	14.0

DESCRIPTION/ JUSTIFICATION

Recent problems in some NASA missions, along with similar or related problems in aerospace and general aviation, are symptomatic of the difficulty in synthesizing operational and design parameters. Safety is a system property, encompassing components, subsystems, software, organizations, human behavior, and their interactions. Yet, typically system design and analysis is de-coupled, addressing only components and subsystems; analysis of risk factors is usually sporadic, and deferred until integration occurs.

Engineering for Complex Systems is a paradigm shift in how systems engineering and operations are performed, and aims to place risk estimation and risk countermeasures for overall mission and human safety on a more rigorous, explicit, and quantifiable basis. This would allow design trades to be evaluated based on a risk factor, with the same fidelity and confidence used for other mission or system properties such as cost, schedule, and performance.

To address the human contribution to errors, and hence risk, models of human performance on certain tasks have been and continue to be developed. Such models, for instance, the frequency of incorrect assembly of a component or performance of some task can be defined as an error probability and built up from prior knowledge of human performance on similar sub-components of the complex task being undertaken. But, determining the required probability distribution functions for such operations can be difficult to obtain, or completely unavailable, causing us to rely on loose estimates, prior experience, or potentially unreliable computation in an uncertain environment.

As such, the key to Engineering for Complex Systems risk assessment will be the ability to reason about very large systems in a logical manner – rather than just by analyzing them mathematically. Indeed this is what the human expert does and the Engineering for Complex Systems program is intended to provide the human expert with a 'cognitive prosthesis' -- an extended reasoning capability -- to allow analysis of much larger systems using a computer's ability to consider very large numbers of alternative combinations.

Although commercial and general aviation would undoubtedly benefit from the research technologies from this program, the spectrum of systems (vehicles and ground operations) of primary focus includes: (1) NASA and commercial space activity; (2) Manned, Reusable, and Expendable Launch Vehicles; (3) Planetary space missions; and (4) Military aerospace vehicles. The ECS Program will be closely coordinated across each of the NASA Enterprises as well as DOD, DOE, NIST, NSF, industry, and universities -- via partnerships and consortia. Customers for ECS developed capabilities, in addition to all of the NASA Enterprises, include aerospace industries, commercial software vendors and developers, and other government agencies, with potential to benefit major industries reliant on interdependent complex technologies – such as the energy development and distribution industry and the transportation industry.

The primary areas of research of the program are:

<u>System Reasoning and Risk Management (SRRM)</u> -- SRRM will conduct research into system complexity, design, and risk propagation profiles. The products from this research and development activity will include tools that better support risk analysis, design robustness, failure modeling, and system trade-offs throughout the entire engineering life cycle of the program. Model Based Reasoning will be a key technology to help systemize and automate the risk analysis, and accommodate the growing size and complexity of current and future programs.

<u>Knowledge Engineering for Safe Systems (KESS)</u> -- KESS will address several key issues. First, human and organizational risk factors play a critical role in all systems and their life-cycle phases, but there is significant under-representation of human and organizational risk factors in current systems engineering tools. Second, to understand the risk that these factors introduce into a system, it is essential to develop technologies and methodologies to capture and discover the effect of the human and organizational interactions - a knowledge management issue. Third, the lack of adequate knowledge management systems for discovery of trends from databases of lessons learned and system historical information must be addressed.

<u>Resilient Systems and Operations (RSO)</u> -- RSO will address Rigid, Non-adaptive Systems, by developing intelligent software technologies that provide robust and resilient operations, as well as advanced testing, validation, and diagnostic tools for risk reduction of these cutting edge software capabilities.

Through these research areas, the program will focus on technologies for understanding potential mishap precursors, addressing currently inadequate methodologies, and capitalizing on critical opportunities. As systems have become more complex and interdependent, the roles of software and human operators are causing problems with greater frequency; in contrast, hardware component failures are a decreasing subset of accident initiators. Current accident models are not adequate to guide risk and safety analyses under these conditions.

Simultaneously, existing probabilistic risk assessment (PRA) technology is unable to account for human errors, software deficiencies, and design flaws. Furthermore, PRA analyses aggregate the probabilities of failure based on linear, de-coupled events; yet events are more tightly coupled due to the increasing complexity. Therefore, new techniques and enhanced uncertainty distributions are needed to explore the large number of combinations for “what if” scenarios.

Although human errors have a higher likelihood of occurring than hardware failures, they are also the most adaptable when an unanticipated hazard occurs. New methods are needed to assess human and organizational risk to support individual and organizational responsibility for success. Learning from the adaptive capabilities of humans, autonomous systems will make systems and missions more resilient.

Another key point is that current knowledge is not available dynamically; instead it is often incomplete and usually inaccessible on demand. ECS will enable knowledge derived from experience and analytical reviews to be available at critical design and decision points.

NASA's Office of the Chief Engineer and Office of Safety and Mission Assurance will provide inputs to ECS on tool needs, requirements, and deliverables that could be incorporated in future NASA engineering and program review processes to improve NASA risk management.

STRATEGIC OBJECTIVE:	**PROGRAM APPROACH:**
Pioneer Revolutionary Technology - Engineering Innovation	Based on past mission mishaps and lessons learned, ascertain maximum coverage of issues that must be addressed, to develop new mishap investigation models including system complexity, human and organizational error, and software failures. Collaborate with industry, academia, and other Government agencies to include methodologies, research, and technologies that may be available from these sources to develop technologies for enhanced probabilistic risk assessment that include full life-cycle distributions of uncertainty. Develop modeling that provides for simulation across every combination of events; and develop reasoning technologies capable of identifying, quantifying, and analyzing risk across the full system life-cycle and which will allow for system response to reconfigure and adapt autonomously. - Infuse these modeling and reasoning technologies and methodologies across NASA Enterprises and collaborating partners, through the application of controlled test-beds to validate their usability at an early stage. Capture and apply lessons learned to allow for dynamic context sensitive advisory systems that support resilient tools to mitigate risk across the full system life cycle

<u>LINKAGES TO STRATEGIC AND PERFORMANCE PLANS</u>

Strategic Plan Goal Supported: Pioneer Technology Innovation
Strategic Plan Objectives Supported: Engineering Innovation
Performance Plan Metrics Supported: APG 3R11

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-03 Change	Comment
Prototype aerospace system mishap database	9/02	9/02	9/02		
Model-based health management system	9/02	9/02	9/02		
Initial organizational risk model	9/03		9/03		
Initial high dependability computing testbed	9/03		9/03		

Program Lead Center: Ames Research Center	**Other Centers:** Jet Propulsion Lab, Johnson Space Center, Kennedy Space Center, Goddard Space Flight Center, Glenn Research Center, Langley Research Center, Dryden Flight Research Center	**Interdependencies:**
Project	**Project Lead Center**	**Industry Contractor (Location)**
System Reasoning & Risk Management (SRRM)	Jet Propulsion Lab	TBD - new program
Knowledge Engineering for Safe Systems (KESS)	Ames Research Center	TBD - new program
Resilient Systems & Operations (RSO)	Ames Research Center	TBD - new program
Program Product	**Builder (Location)**	**Product Benefit**
SRRM - Integrated Risk Management technologies	Expected multi-contractor/university effort	Develop integrating frameworks and architectures to apply traditional risk models, SRRM developed models, and other technologies to improve risk assessment. This will include methods and tools to integrate both qualitative and quantitative information/knowledge in normative risk management decision-making process.
SRRM - Integrated System Modeling & Reasoning	Expected multi-contractor/university effort	Develop and mature tools that use models of system structure, behavior and function to identify hazards and assess risk. Understand how system mishaps occur, with particular emphasis on the role of system complexity as a contributing factor, and on analyzing complex designs using model-based methods for identifying potential system accidents.

SRRM - Sub-System Model Integration Methods	Expected multi-contractor/university effort	Develop and mature subsystem performance and failure models to be integrated into a larger analytical framework for assessing contributive risk of those subsystems.
KESS - Human & Organizational Risk Management	Expected multi-contractor/university effort	Develop methodologies to assess and mitigate human and organizational contributions to risk. Conduct research into the factors involved in individual/team decision making, including how people make decisions and take action, and how safety and risk in both operational and design context is assessed -- examine from individual, team and organizational cognitive perspectives. Develop knowledge products useful for mitigating risks under operational contexts.
KESS - Knowledge Management	Expected multi-contractor/university effort	Develop methodologies and tools to assist in the effective management of large, heterogeneous, distributed, and dynamic data and information systems.
RSO - Intelligent & Adaptive Operations & Control	Expected multi-contractor/university effort	Develop integrated autonomous operations and low-level adaptive flight control technologies to direct actions that enhance the safety and successes of complex missions despite component failures, degraded performance, operator errors, and environmental uncertainty.
RSO - Resilient Software Engineering	Expected multi-contractor/university effort	Develop software engineering tools and methods to reduce the risk of software in complex systems. Emphasis will be on techniques that use well defined, comprehensible and analyzable specifications of systems components and software requirements to manage risks introduced by technical communication gaps among life cycle phases, organizations, and subsystem elements.

PROGRAM STATUS/PLANS THROUGH 2002

In FY 2001 the **Engineering for Complex Systems (ECS)** Program a preliminary analysis of multiple case studies was performed. An initial program concept was defined, and presented at a 2-day workshop with participation from all NASA centers, academia, other Government agencies, and industry. Additionally, multiple workshops were held at the project levels to examine the proposed content. A call for technical concepts and capabilities was made across the agency, providing extensive insight into the current and proposed work from NASA in these areas. Technologies and concepts from other programs were discussed and additional information was obtained, including potential synergies to mature the technologies through the Technology Readiness Level band.

A study of existing technologies applicable to ECS solution set domains, performed by Andersen LLP (Global Aerospace Practice), was based on the initial work breakdown structure. A preliminary assessment of current industry investment in each of the technologies was made through interviews of industry and academia. The results of this study identified areas where industry investment (current and projected) was sufficient to cover technology needs; it also uncovered areas that required additional investment than planned. As a result of this, the work breakdown structure was adjusted to the current content.

A second study, performed by Battelle Labs, proposes measurement approaches for each ECS element for a set of success criteria with practical validated metrics to continuously track progress. Additionally, Battelle characterized alternative approaches to developing quantitative metrics to measure NASA's risk profile and track progress towards enterprise-wide risk reduction goals.

In FY 2002, the Mishap Cause Classification is being performed to define strategic investment areas and educate program personnel about mishap causes. The approach included the definition of a standard taxonomy for classification of mishap causes, which was validated by applying it to a sample of approximately 25 mishap investigations. In addition to this initial sample additional data from Aerospace Corporation and other industry sources will be analyzed utilizing the same taxonomy.

Additionally, ECS has developed program and project plans, decision packages, and detailed briefings for the Program Readiness Review, leading to the Non Advocate Review as a FY 2002 program. Also, long lead items and final feasibility and risk reduction tasks will be implemented during this time period. Planning for a NASA Research Announcement (NRA) solicitation to academia and industry is part of this process. The NRA constitutes a multi-year strategy to invest in key technologies and demonstrate those with the highest risk mitigation potential through applications projects.

PROGRAM PLANS FOR FY 2003

The **ECS Program** will develop the initial model of organizational risk that will serve as the basis for subsequent milestones. This tool will capture and analyze data relevant to social/organizational systems risks. Testing and validation of the model will be mission specific. High-fidelity testbeds will provide initial simulation of at least two NASA software systems; addressing risks in areas of dependability, performance/risk management, and complex, intelligent systems. These products will provide the basis to meet program objectives and deliver tools such as adaptive systems that can learn and react to complex and dynamic environments (FY 06) and decision tools for organizational risk management (FY 05).

BASIS OF FY 2003 FUNDING REQUIREMENT

COMMERCIAL TECHNOLOGY PROGRAMS

Web Address: http://www.nctn.hq.nasa.gov

	FY 2001	FY 2002	FY 2003
	(Millions of Dollars)		
Commercial Technology Programs	**162.4**	**163.8**	**146.9**
Commercial Programs and Technology Transfer Agents	51.3	48.7	35.6
Small Business Innovation Research Programs	111.1	115.1	111.3

DESCRIPTION/JUSTIFICATION

NASA's Commercial Technology Program includes Commercial Programs, Technology Transfer Agents and the Small Business Innovative Research (SBIR) Program. NASA's Commercial Technology Program enhances the NASA R&D mission through technology partnerships with industry, and facilitates the transfer of NASA inventions, innovations, discoveries or improvements developed by NASA personnel or in partnership with industry/universities to the private sector for commercial application leading to greater U.S. economic growth and competitiveness.

Commercial Programs introduces a balanced compliment of practices and techniques, which enable the Agency to more closely align and leverage its way of doing business with that of the private sector. The common denominator in these practices is technology partnerships. Technology partnerships are business arrangements among government, industry, and/or academia wherein each party commits resources to the accomplishment of mutually agreed upon objectives and shares the risks and rewards of the endeavor. By working together, NASA and industry can accelerate the incorporation into NASA of technologies of joint interest as well as commercial application further and faster, while also reducing the costs to both parties.

The success of Commercial Programs is accomplished through:

- The establishment of productive joint technology development and application partnerships with industry.
- An extensive outreach program (technology dissemination and marketing);
- An e-commerce and technology information management network (via the Internet) that greatly facilitates the establishment of dual use technology partnerships with industry and transfer of technology, and which enables very efficient management of our technology business contacts and services;
- Training and education of NASA employees to emphasize program relevance to national needs and to incorporate commercial practices in R&D program implementation;
- The use of performance metrics that addresses management processes as well as bottom-line results;

The goal of Commercial Programs is to share the harvest of NASA's technology programs with the U. S. industrial/scientific community. The goal encompasses the commercialization of technology developed in all the Agency's Enterprises, in the recent past as well as current programs. The NASA Commercial Program mission includes a variety of mechanisms for achieving its goals: partnerships with industry/academia; federal/state/local alliances; emphasis on commercialization in new R&D procurements; electronic commerce; training and education of NASA employees/contractors; employee accountability; and application of performance goals/metrics.

The goal of Technology Transfer Agents is to facilitate the joint development of mission relevant technology and transfer of NASA (and associated capabilities) to the U. S. private sector for commercial application. The purpose of this program goal is to enhance U. S. industrial growth and economic competitiveness.

Established by Congress, the goal of the SBIR program (which includes NASA's Small Business Technology Transfer (STTR) programs) is to help NASA develop innovative technologies for use in its missions through competitive research contracts to U.S.-owned small businesses.

NASA's SBIR program pursues the widest possible award of NASA research contracts to the small high tech business and research community and promotes commercialization of the results of this research by the small business community.

Objective:	Commercial Technology **PROGRAM APPROACH**
Commercialize Technology	Establish R&D partnerships with industry to enhance the development of NASA mission technology, and to promote the application of NASA technology in US industry.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Commercialize Technology
Strategic Plan Objectives Supported: Commercial Technology Programs
Performance Plan Metrics Supported: 3P7, 3CK3

Milestones	**FY03 Date**	**FY02 Date**	**Baseline Date**	**FY02-03 Change**	Comment
Establish technology partnerships with industry	9/03		9/03		
Transfer NASA technology and innovations to the public sector	9/03		9/03.		

Lead Center:	Other Centers:	Interdependencies:
All centers involved	**All NASA centers & JPL**	
		Project Benefit Establish technology partnerships with industry at a level so that 10% - 20% of NASA's R&D activity is involved in partnerships. Expand the industry sector joint R&D initiatives to leverage industry R&D capabilities to enhance NASA mission focused R&D projects. Include 5 key NASA technology areas in the commercial industry sector initiative. Communicate to the public and to private industry the breadth and depth of NASA technology that is available for use in commercial products and services.

PROGRAM PLANS FOR FY 2003

Initiate plans to leverage and enhance the SBIR program through innovative business-like, but independent, venture capital organization.

Establish new approach to technology sponsorship activities through innovative partnerships with US industry.

Expand joint technology development activities with industry to enhance the return and value to NASA mission R&D programs. This action will include the establishment of new and/or enhanced performance metrics.

BASIS OF FY 2003 FUNDING REQUIREMENT

SBIR/STTR

Web Address: http://www.nctn.hq.nasa.gov

	FY 2001	FY 2002	FY 2003
		(Millions of Dollars)	
SBIR/STTR Program	**111.1**	**115.1**	**111.3**

DESCRIPTION/JUSTIFICATION

The (SBIR) program and Small Business Technology Transfer (STTR) Program help NASA develop innovative technologies by providing competitive research contracts to U.S.-owned small businesses and research institutions.

The SBIR/STTR programs include activities to enhance the commercialization of SBIR/STTR technology and to periodically assess the commercial performance of the NASA SBIR program.

Milestones	FY03 Date	FY02 Date	Baseline Date	FY02-03 Change	Comment
Issue SBIR/STTR solicitation	7/03		7/03		
Select SBIR awardees	12/03		12/03		

SBIR PROGRAM STATUS/NOTIFICATIONS/PLANS THROUGH 2002

Accomplished issuance of the SBIR solicitation and selection of awardees milestones as planned, and published the first edition of the SBIR commercial assessment. Complete installation of end-to-end web based solicitation, review, award, and contract administration in e-commerce environment.

SBIR PROGRAM PLANS FOR FY 2003

Complete the solicitation and selection actions milestones as scheduled. Issue an update to the SBIR commercial assessment study Develop new pilot program to enhance the SBIR technology utilization in NASA mission programs, and to leverage the investment community to promote commercial performance.

BASIS OF FY 2003 FUNDING REQUIREMENT

AEROSPACE INSTITUTIONAL SUPPORT

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET
		Millions of Dollars)	
Research and Program Management (R&PM)	[712.1]	[805.0]	857.7
Labor	[571.9]	[608.8]	663.7
Travel	[15.5]	[16.2]	19.9
Research Operations Support (ROS)	[124.7]	[179.8]	174.1
Environmental	[12.6]	[20.7]	59.4
Construction of Facilities (CoF) - (Non-Programmatic)	[84.0]	[64.3]	56.1
Institutional Support to Aerospace Technology	**[808.7]**	**[889.8]**	**973.2**
Johnson Space Center	[0.4]	[4.7]	4.8
Kennedy Space Center	[7.9]	[5.7]	6.3
Marshall Space Flight Center	[83.8]	[101.8]	126.2
Stennis Space Center	[43.1]	[23.1]	21.4
Ames Research Center	[145.2]	[153.6]	148.8
Dryden Flight Research Center	[51.1]	[62.8]	63.2
Langley Research Center	[199.0]	[210.3]	218.0
Glenn Research Center	[174.6]	[175.0]	225.6
Goddard Space Flight Center	[13.7]	[11.9]	13.2
Jet Propulsion Laboratory	[0.6]	[0.8]	0.7
Headquarters	[89.3]	[140.1]	145.0
Distribution of Program Amount by Installation	**[808.7]**	**[889.8]**	**973.2**

* Numbers in brackets are the prior year totals to reflect a correct representation of the cross-year funding levels.
** The FY 2002 Funding estimate for ROS includes $8.0M provided in the Emergency supplemental to enhance NASA's security and counter-terrorism capabilities.

PROGRAM GOALS

The two primary goals of this budget segment is to:

1. Acquire and maintain a civil service workforce that reflects the cultural diversity of the Nation and is sized and skilled consistent with accomplishing NASA's research, development, and operational missions with innovation, excellence, and efficiency for the Aerospace Technology Enterprise.

2. Ensure that the facilities critical to achieving Aerospace Technology Enterprise program goals are constructed and continue to function effectively, efficiently, and safely; resources are focused on high-priority facilities by appropriately managing underutilized, outdated, and low-priority facilities; and that NASA installations conform to requirements and initiatives for the protection of the environment and human health.

RESEARCH AND PROGRAM MANAGEMENT (R&PM): provides the salaries, other personnel and related costs, travel and the necessary support for all administrative functions and other basic services in support of research and development activities at NASA installations. The salaries, benefits, and supporting costs of this workforce comprise approximately 79% of the requested funding. Administrative and other support is approximately 19% of the requests. The remaining 2% of the request is required to fund travel necessary to manage NASA and its programs.

CONSTRUCTION OF FACILITIES (CoF): provides for discrete projects required for capital repair of basic infrastructure and institutional facilities. Some NASA facilities are critical for the Aerospace Technology Enterprise and to military and private industry users. NASA has conducted a thorough review of its facilities infrastructure finding that the deteriorating plant condition warrants an increased repair and renovation rate to avoid safety hazards to personnel, facilities, and mission; and that some dilapidated, outdated, or underused facilities need to be replaced or shut down. Increased investment in facility revitalization is needed to maintain a facility infrastructure that is safe and capable of supporting NASA's missions.

ROLES AND MISSIONS

The detail provided here is for the support of the Aerospace Technology Enterprise institutions - Ames Research Center, Dryden Flight Research Center, Glenn Research Center, Langley Research Center, Marshall Space Flight Center, Stennis Space Center, and Goddard Space Flight Center.

AEROSPACE TECHNOLOGY RESEARCH CENTERS

AMES RESEARCH CENTER (ARC)

The Aerospace Technology Enterprise funds approximately 66% of ARC's Institution cost. ARC conducts aeronautics research in ground-based and airborne automation technologies, human factors, and operational methodologies for safe and efficient airspace operations. ARC provides Agency-wide leadership in conducting research and technology development to enable and foster the intelligent vehicle of the future through the implementation of integrated vehicle health management as a vehicle discipline. They provide high-fidelity flight simulations to support national goals in aviation safety and capacity, as well as vehicle development requirements. ARC conducts research, spanning computation through flight, for high-performance aircraft, to improve efficiency, affordability, and performance. ARC is also developing an integrated set of experimental and computational technologies built around an embedded information systems backbone, to provide rapid, accurate vehicle synthesis and testing capabilities.

ARC scientists and technologists conduct research on advanced thermal protection systems and perform arcjet testing to meet national needs for access to space and planetary exploration. ARC is the lead center for information technology efforts in the ECS program (formerly called Cross-Enterprise Technology). In addition, Ames is the lead center for the Intelligent Systems program, which provides critical, next-generation information technology capabilities for NASA missions and activities.

DRYDEN FLIGHT RESEARCH CENTER (DFRC)

The Aerospace Technology Enterprise funds approximately 88% of DFRC's Institution cost. DFRC develops, manages, and maintains facilities and testbed aircraft to support safe, timely, and cost-effective NASA flight research and to support industry, university, and other government agency flight programs. Dryden personnel conceive, formulate, and conduct piloted and unpiloted research programs in disciplinary technology, integrated aeronautical systems, and advanced concepts to meet current and future missions throughout subsonic, supersonic, and hypersonic flight regimes. DFRC also provides flight test support for atmospheric tests of experimental or developmental launch systems, including reusable systems. DFRC's flight research programs are conducted in cooperation with other NASA installations, other government agencies, the aerospace industry, and universities.

GLENN RESEARCH CENTER (GRC)

The Aerospace Technology Enterprise funds approximately 73% of GRC's Institution cost. As the NASA Lead Center for Aeropropulsion, GRC conducts world-class research critical to Aerospace Technology Enterprise goals of developing and transferring enabling technologies to U.S. industry and other government agencies. The Center's Aeropropulsion programs are essential to achieving National goals to promote economic growth and national security through safe, superior, and environmentally compatible U.S. civil and military aircraft propulsion systems. The Aeropropulsion program at GRC spans subsonic, supersonic, hypersonic, general aviation, high-performance aircraft, as well as access-to-space propulsion systems. The program pursues innovative applications of research in turbomachinery materials, structures, internal fluid mechanics, instrumentation and controls, interdisciplinary technologies, and aircraft icing. GRC has research expertise in world-class facilities critical to ensuring U.S. leadership in aviation. FAA, EPA, and DOD in particular depend on NASA GRC research for advancements in emissions, noise, engine performance and new materials.

As the NASA Center of Excellence in Turbomachinery, GRC expertise is critical to advancing the Agency's goals in our aeronautics and space programs and enables GRC to be a cost-effective resource across multiple Agency programs. Turbomachinery-based areas of expertise include air breathing propulsion and power systems, primary and auxiliary propulsion and power systems, on-board propulsion systems, and rotating machinery for the pumping of fuels/propellants.

LANGLEY RESEARCH CENTER (LaRC)

The Aerospace Technology Enterprise funds approximately 79% of LaRC's Institution cost. LaRC conducts advanced research in fundamental aerodynamics; high-speed, highly maneuverable aircraft technology; hypersonic propulsion; guidance and controls; acoustics; and structures and materials. LaRC provides technology base for improving transport, fighter, general aviation, and commuter aircraft. LaRC scientists and technologists conducting to study current and future technology requirements, demonstrate technology applications, and conduct theoretical and experimental research in fluid and flight mechanics to determine aerodynamic flows and complex aircraft motions. LaRC also conducts research to develop technologies and capabilities that permit the integration of widely distributed science, technology, and engineering teams and that provide advanced tools enabling the teams to create innovative, affordable products rapidly.

LaRC develops innovative new airframe systems to improve safety, reduce emissions and cut noise levels. These new airframe systems technologies improve environmental compatibility, increase capacity, and reduce cost per seat mile of commercial transport and general aviation aircraft. LaRC technologists conduct control and guidance research programs to advance technology in aircraft guidance and navigation, develop aircraft control systems, improve cockpit systems integration and interfacing techniques, and enhance performance validation and verification methods. LaRC also conducts research in aircraft noise prediction and abatement. LaRC personnel are pioneering the development of new materials, structural concepts, and fabrication technologies to revolutionize the cost, performance, and safety of future aircraft structures while creating radically new aircraft designs. LaRC provides Agency wide leadership and strategically maintains or increases the nation's preeminent position in structures and materials by serving as the NASA Center of Excellence for Structures and Materials.

LaRC scientists and technologists also conduct aeronautics and space research and technology development for advanced aerospace transportation systems, including hypersonic aircraft, missiles, and space access vehicles using airbreathing and rocket propulsion. Specific technology discipline areas of expertise are aerodynamics, aerothermodynamics, structures, materials, hypersonic propulsion, guidance and controls, and systems analysis. LaRC also conducts long-range studies directed at defining the technology requirements for advanced transportation systems and missions. In addition, LaRC develops technology options for realization of practical hypersonic and transatmospheric flight.

MARSHALL SPACE FLIGHT CENTER (MSFC)

The Aerospace Technology Enterprise funds approximately 33% of MSFC's Institution cost. The MSFC is the NASA Lead Center for space transportation systems development. The MSFC FTE's plan, direct, and execute research, technology maturation, advanced design and development, and sustaining engineering for NASA's next-generation space transportation systems. These systems include reusable launch vehicles and other associated transportation systems and subsystems. MSFC integrates program and project level planning, research, and development to ensure a well-balanced space transportation development program that meets the Agency's aggregate needs in a coordinated and integrated manner. MSFC develops technology in vehicle and propulsion systems, advanced manufacturing processes, and materials and structures. The Center conducts technology efforts, under contract including cooperative agreements, with the U.S. launch vehicle industry, to improve the competitiveness of current systems.

STENNIS SPACE CENTER (SSC)

The Aerospace Technology Enterprise funds approximately 35% of SSC's Institution cost. SSC supports the development of new and innovative propulsion technologies by providing propulsion test capabilities for the Space Launch initiative, including both 2nd Generation and 3rd Generation systems.

GOODDARD SPACE FLIGHT CENTER (GSFC)

The Aerospace Technology Enterprise funds approximately 3% of GSFC's Institution cost. GSFC directs the Wallops Flight Facility which provides institutional and technical support to LaRC, other NASA centers, and commercial users, who conduct flight studies of new approach and landing procedures using the latest in guidance equipment and techniques, pilot information displays, human factors data, and terminal area navigation.

HEADQUARTERS

The Aerospace Technology Enterprise funds approximately 37% of Headquarters' Institution cost. The Enterprise's Institutional Support figure includes an allocation for funding Headquarters activities based on the relative distribution of direct FTE's across the agency. A more complete description can be found in the Mission Support/two Appropriation budget section.